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ABSTRACT

This paper outlines a process that can be applied to the analysis or design of instructional programs and materials. The role of values in decision-making is discussed, with special emphasis on desisions concerning energy education. In addition, some criteria are given for effective programs and instructional materials for energy education. This paper addresses the needs of three kinds of decision-makers: (1) purchasers of instructional materials and programs; (2) persons responsible for allocating funds; and (3) designers of materials and programs. Extensive lists of questions, comprising a major portion of this paper, represent the means by which the analyzer can glean appropriate information from instructional material and by which the designer and the funder can check to see that specifications for proposed materials are complete. An instructional unit on energy for elementary schools is included as an example of the application of some of the principles discussed. (Author/BB)

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CRITERIA FOR EFFECTIVE ENERGY EDUCATION

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In preparing this paper, we had in mind the needs of those individuals who must make decisions concerning instructional materials and programs for energy education.[1] In particular, the paper addresses the needs of three kinds of decision makers: persons responsible for purchasing or selecting energy education instructional materials and programs (purchasers); persons responsible for allocating funds for the development of such materials and programs (funders); and persons actually responsible for designing such materials and programs (designers). Contained in this paper are the guidelines that will aid (a) purchasers in analyzing and evaluating instructional materials and programs; (b) funders in analyzing and evaluating proposed specifications for the development of instructional materials and programs,

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[1] We limit our discussion of energy education to instructional materials and programs for students in schools. Providing for energy education, however, involves the school in more than its customary role of purveying knowledge. It also calls for effecting changes in the out-of-school behaviors of students, an outcome not included among the objectives of most instructional materials intended for use in the schools.

and (c) designers in planning for and determining specifications for the development of instructional materials and programs.[2]

The paper outlines a process that can be applied to the analysis or design of instructional programs and materials. We also discuss the role of values in decision making, with special emphasis on the role of values in making decisions concerning energy education. In addition, the paper presents some of our criteria for effective programs and instructional materials for energy education.[3]

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[2]Some examples of each type of educational decision maker we have in mind (purchaser, funder, and designer) and the kinds of public and private agencies with which they might be associated are presented here.

Persons concerned with purchase or adoption of energy education programs and instructional materials will most likely work with schools or state departments of education. Their positions include those of teacher, curriculum specialist, administrator, and adoption officer.

Persons concerned with the funding of energy education programs and materials will be found in a wide variety of agencies ranging from publishers, government agencies, and foundations to utility companies and consumer organizations. Their positions include those of executive editor, peer reviewer, and project director as well as that of consumer education specialist.

Persons concerned with the design of energy education programs and materials might be associated with schools, publishers, or educational research and development organizations. Persons affiliated with utility companies and consumer organizations might also have such design responsibilities. The positions of persons involved with energy education materials design include those of teacher, curriculum specialist, curriculum designer, and educational materials writer or editor.

[3]The distinction we make between the terms instructional materials and instructional program relies on our definition of an instructional material as any item, be it a manipulative or a printed material, that is intended to be used for an instructional purpose. Our definition of instructional program, on the other hand, refers to a number

Both in analyzing and designing instructional materials, carefully conceived procedures are necessary to insure that attention has been paid to each aspect of the materials. The process of analyzing instructional materials requires the systematic gathering of information, while the process of instructional design demands systematic attention to the multitudinous details involved in the conceptualization and production of instructional materials. Extensive lists of questions, comprising a major portion of this paper, represent the means by which the analyzer can glean appropriate information from instructional materials and by which the designer and the funder can check to see that specifications for proposed materials are complete.

The questions have been organized into nine tables (shown in Appendix A as Tables A-1 through A-9), each of which pertains to one of nine major components of instructional programs. In our experience, not all decisions concerning instructional materials rely on information about all nine of these components. Figure 1 illustrates our experience in regard to the importance of each component for different types of educational decision making. Decisions made by funders or purchasers of instructional programs and materials are generally based on information from only selected components. On the other hand, designers of instructional materials and programs must have information related to all of the components.

Designers, purchasers, and funders differ also as individuals with respect to the relative importance they give to each component in the decision-making process. For example, it is generally the

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of instructional materials integrated by means of an overall plan that directs how the materials are to be used in conjunction with one another toward the achievement of one or more instructional purposes. In the following sections of this paper, we have generally used the terms <u>instructional materials</u> and <u>instructional programs</u> to refer to both ideas interchangeably. It will be clear from the context when a specific meaning is appropriate for one or another of the terms.

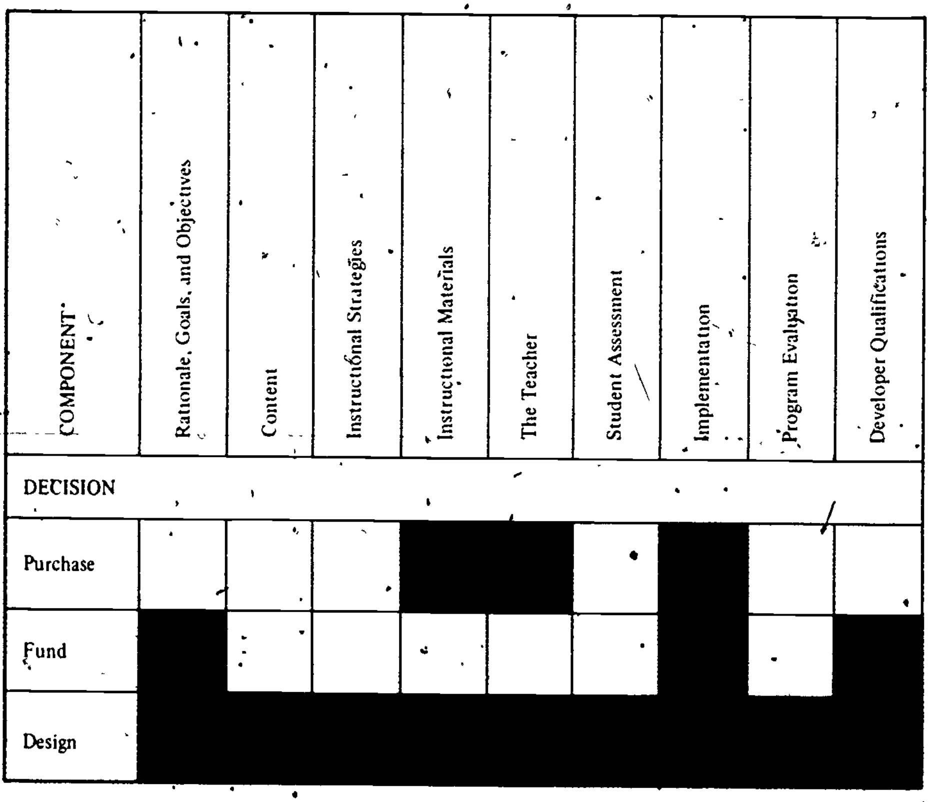

Figure 1 Components of instructional programs which generally receive primary consideration in decision making.

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case that several competent designers will make varying decisions concerning the design of particular instructional materials even when each person's decision is based on the same information. All competent designers will, however, be knowledgeable about the parameters of potential decisions related to each component and will be able to provide rationales for the decisions they make. A more concrete illustration of this principle can be seen in the context of decisions made by materials purchasers. Some individuals faced with a purchasing decision give primary consideration to the cost or physical appearance of the instructional materials. Others faced with making the same decision will focus their attention on the ease with which the materials can be implemented in the classroom or on the demands that the program places on the teacher. Only the most sophisticated of potential purchasers will base their decisions on the more technical aspects of the materials' design--for example, the use of principles of instructional theory in their design. Most purchasers find it very difficult, if not impossible, to carry out sophisticated analyses of materials of the sort that would determine, for example, how well the materials fit the educational goals of the school system.

Individuals faced with making funding decisions often give primary consideration to the designers' reputation, the completeness of the development plan, or the appropriateness of the proposed materials for the target population. Publishers, for example, base many of their funding decisions on the cost of the product to the purchaser and on the size and characteristics of the potential user population. Often funders must rely on the expert judgment of the designers in regard to the more technical decisions related to instructional design. Just as with potential purchasers, it is sometimes, but not often, the case that funders are as knowledgeable as the most competent designer and can make more substantive analyses and evaluations of specifications for instructional materials on all of the components toward which the questions presented in this paper are addressed.

The questions in the tables provide a mechanism for the systematic gathering of information, a necessary but not sufficient condition for informed decision making. We believe that, in addition to information, values are central to all decision-making processes, including those involved in the processes of designing, funding, and purchasing energy education materials and programs. In design, for example, decisions are made about the rationale for the program or materials, the content, the packaging, the student activities, the teacher's role, and many other matters. The decisions that are made reflect the values of those who make them. A certain program may, for instance, devote considerable attention to teaching children about the amount of coal and oil in the earth but little space to the question of how alternative sources of energy might be developed. This distribution of content suggests that the designers have placed more value on knowledge of facts than on knowledge of processes. Decisions about content made by an energy education program's designers reflect particular values.

The process of selecting instructional materials for purchase is also a matter of making decisions based on values. In purchasing, decisions are made concerning which materials will be selected, how they will be used, with whom, etc. Because choices exist, decisions must be made. The amount of time and money a school district is willing to expend on energy education reflects the value that the school places on energy education. Additional considerations in the selection process also reflect values; for example: Should the materials be individualized? Should they emphasize conservation? Will they deal with political and economic issues? Questions such as these consider values, that is, what the school and the community who will use the instructional materials judge to be important, worthwhile, or "good."

Because decisions made about energy education are value-laden, we believe it is important that the values inherent in instructional

materials be explicit. If they are, the work of persons who must make decisions about such materials--whether or not to fund a development project, whether or not to purchase materials for a school, or a similar major decision--will be facilitated by allowing these decisions to be made on a rational, informed basis. For the same reasons, we feel that specifying the values intrinsic to the materials will also aid the designers in their work.

The functions of information and values are interactive in the decision-making process and, therefore, can never be treated as discrete entities. The questions we pose for your use, our discussion of the importance of the information that the answers contain, and the criteria for effective energy education we put forward for your consideration are all reflections of our values. One of our values is a high regard for public education. Also, we believe that the proper kinds of instructional materials can play a significant role in enabling the nation to cope with the energy dilemma.

Some persons may challenge this assertion, but we suspect that their doubts stem from a failure to recognize the potential of recent developments in the field of instructional technology. Principles of instructional technology that have become known, codified, and validated through research in recent years can be successfully applied to the processes of designing and analyzing educational materials.[4] Many instructional materials of the past have failed because these principles were either not applied or inappropriately applied in the course of the materials' development. Often, too, well-designed materials have failed because they were improperly implemented or even poorly

[4] The literature on systematic instructional procedures is already quite large and is growing rapidly. For representative examples, see Travers (1973); Resnick, Wang, and Kaplan (1973); and Popham and Baker (1970).

matched to the needs of the school system that purchased them. Considerable experience has been gained during the last decade and a half in designing, analyzing, and implementing instructional materials. Such experience now makes it possible to suggest with some assurance necessary conditions for the design, selection, and implementation of effective and successful instructional materials for schools. We value also the application of systematic procedures to the processes of analysis, design, and implementation of instructional materials.

These are our values; they determine our criteria for instructional materials. The questions in the tables reflect the application of some of our values to the process of establishing criteria. Consider for example question B. 9 in Table A-1 (Appendix A), "Are there explicitly stated objectives corresponding to all the program's goals?" Because we value a systematic design process, we would include the presence of behaviorally stated objectives as one of our criteria for effective instructional materials. That is not to say that the only right answer to question B. 9 is "yes." There are effective instructional materials that do not contain explicitly stated behavioral objectives. A "no" answer should, however, result in further analysis of the instructional materials in order to determine if the functions served by behavioral objectives have been adequately met.

The illustration in the preceding paragraph is intended to emphasize that the particular answers that result from the application of the questions presented in our tables to any particular instructional materials do not determine in themselves the potential effectiveness of those materials. The information resulting from the answers to the questions must be considered in the context of criteria which you set, based on the values you hold. In the following discussions of issues relating to components of instructional materials, we set forth certain of our criteria, but you must set your own criteria after considering the issues we raise.

Rationale, Goals, and Objectives

Before discussing our criteria for the rationale, goals, and objectives of energy education programs and instructional materials, it is necessary for the sake of clarity to indicate what we mean by the terms "rationale," "goals," and "objectives." For our purposes, the rationale of a program is a statement that explains such matters as why the development of the program was undertaken, what societal needs the program was developed to respond to, and what were the underlying assumptions of the program's designers. By "goals" we mean, simply, the broad aims that the program or the materials are designed to achieve. The goals of a program of energy education presumably would include such things as increasing students' knowledge about energy and changing their behaviors related to energy consumption. Objectives are much more specific statements of the outcomes that various parts of a program are designed to produce.

Decisions that must be made in the course of developing or selecting energy education materials will be facilitated by the kinds of information that are available in carefully thought out and written statements of rationale, goals, and objectives. Because of the value we attach to developing educational materials systematically and on a rational basis, the first considerations in this development, we believe, should be those surrounding a program's rationale, goals, and objectives. The "nitty-gritty" decisions about the development of a program--will it include manipulative activities, will media other than print be used, etc.--can be made rationally only after decisions have been made about why the program is needed and what it aims to achieve in both general and specific terms. Reversing the order of these kinds of decisions can easily lead to programs that are incoherent, inconsistent, and ineffective.

We also believe that the process of selecting a program or materials for purchase will be expedited if, early in the selection

process, careful attention is given to the rationale, goals, and objectives of the programs and materials under consideration. If, for example, a program espouses goals that are quite inconsistent with the goals of the community where the program will be used, the program can probably be eliminated from consideration.

From our analysis of the energy dilemma and the role of education in it evolve our criteria for the rationale and goals of energy education materials that we would judge to be potentially effective.

This is our analysis of the dilemma. In the years to come, the demand for energy will exceed the supply. Costs of delivering energy will continue to increase. Increased use of energy will further deplete our natural resources and influence the ecological balance of the environment. Individuals confronting the energy dilemma will be forced to make decisions and choices; their concerted decisions will influence national energy policy and their individual choices will determine their life styles.

This situation requires citizens who are knowledgeable, who are aware of their personal values, who are skillful problem solvers and decision makers, who have well-defined personal goals, and who are able to predict the consequences of their energy choices and decisions, both for themselves and for the society in which they live.

This analysis has these implications for energy education. Energy education must be multifaceted, that is, it must not only convey information, but also deal with social, economic, political, and moral issues. In addition, it must make provision for increasing individuals' abilities to define their values and goals, to solve problems, and to make decisions. Our analysis also suggests some criteria for the rationale and goals of energy education programs. The rationale and goals of such programs should reflect the multifaceted nature of energy education. The philosophical, psychological, social, scientific, and political assumptions underlying the rationale and goals should also be specified,

as we have stated, to guide the work of the designers and to facilitate understanding of the program by others. Section A of Table A-1 (Appendix A) presents questions that the decision maker can use to gather information about a program's rationale. Questions about the goals of energy education programs and materials are included in Section B of Table A-1.

As the heading indicates, the questions that comprise Section B of Table A-1 deal with the conceptualization of an energy education program, that is, the relationship of the program's rationale to its goals, of its goals to its objectives, and its objectives to its instructional materials. The information that one gathers by asking these questions is useful in making judgments about a program's consistency and coherence, two important prerequisites for effectiveness.

Section B of Table A-1 also presents a number of questions regarding the statements of objectives. It is our opinion that an important process in operationalizing the goals of a program is the translation of the program's goals into specific objectives. Objectives can serve a variety of functions. The format of the objectives determines, in part, the extent to which the objectives can serve the functions. For example, objectives that are stated behaviorally--in terms of observable student behaviors--are useful as means of communicating the designers' ideas about the effects of the program to the teachers who implement the program. Educators rely on observations and descriptions of overt behaviors to infer the state and organization of an individual's knowledge. It follows, therefore, that behaviorally stated objectives are also useful starting points for assessing the extent to which the program has attained its goals. The use of behavioral objectives is sometimes criticized because they so often describe trivial behaviors. This need not be the case, however. In fact, a program can be evaluated in part on the extent to which its objectives sample

behaviors from all levels of the cognitive and affective domains as described by Bloom (1956) and Krathwohl, Bloom, and Masia (1964).[5]

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[5]In addition to aiding communication and the assessment of the effects of instruction, stating educational objectives behaviorally facilitates the selection of appropriate instructional strategies. (See page 19 of this paper.)

Benjamin Bloom was instrumental in providing educators and psychologists with an important tool, a taxonomic system for grouping together behaviors that have specified attributes in common. In this taxonomy, behaviors are classified into three major groups, called domains, according to whether they are primarily cognitive, affective, or psychomotor behaviors. Of course, the division of behaviors into these three domains is an artificial distinction since almost any behavior ordinarily is made up of cognitive, affective, and psychomotor elements. For example, behaviors relating to conserving energy in the home might rely partly on knowledge of ways to conserve energy, partly on the desire to conserve energy, and partly on the physical ability to perform tasks that aid in conserving energy, such as shutting off a light switch. Nevertheless, the classification of behaviors provides some extremely useful tools for educators.

Within each domain of the taxonomy, specific behaviors are arranged hierarchically in terms of their complexity. To illustrate this hierarchical arrangement, let us examine some examples of behavior from the cognitive domain. The first level of the cognitive domain is <u>knowledge</u>--behaviorally stated, the ability to recall specific information, e.g., knowledge of some ways that energy might be conserved in the home. The second level of the cognitive domain, <u>comprehension</u>, involves such behaviors as the ability to explain why insulating one's house will conserve energy. The third level, <u>application</u>, is exemplified by the behavior of applying the idea of energy conservation to an area where one has not yet learned ways of conserving energy. An example illustrating the fourth level, <u>analysis</u>, is the ability to recognize various techniques of energy conservation, e.g., using a single energy source for two or more different purposes simultaneously. The fifth level, <u>evaluation</u>, calls for such behaviors as the ability to compare various energy conservation plans proposed for one's family and to select one of them on the basis of the amount of energy it conserves and the likelihood that one's family will be able to adhere to it without undue hardship.

Figure 2 shows some examples of behavioral objectives from several levels of the cognitive domain; Figure 3 presents behavioral objectives from all five levels of the affective domain. These objectives from the affective domain are particularly important to energy education since, as can be seen in Figure 3, they are concerned with the student's behavior outside the classroom. They are also closely related to the processes of values clarification, goal setting, and decision making, processes we believe are essential parts of energy education.[6]

Finally, Section C of Table A-1 lists some questions about the planning of proposed new programs or materials for energy education. The questions will be of special interest to persons considering undertaking the development of such programs and to those who must evaluate plans for materials development projects.

Content

The content of an energy education program must reflect and support the goals and objectives of the program. Since the goals and objectives of an effective energy education program encompass a variety of behaviors and an extensive knowledge base, the content of such a program will, of necessity, include both skills and knowledge areas. Thus, our criteria include considerations both of the information and knowledge conveyed to the student (the cognitive domain) and of the skills in values clarification, goal setting, problem solving, and decision making (which have behavioral components in both the cognitive and the affective domains).

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[6] We shall discuss these processes more fully in a later section of this paper in relation to the instructional strategies employed in energy education.

BEHAVIORAL OBJECTIVES

1. The student identifies the following attributes of energy: energy can change things, energy added to a system changes the system; energy has different forms; energy can be converted from one form to another form.

3. The student gives examples from his own experience of heat energy and light energy changing a system.

6. The student describes the energy conversions in various systems e.g., a lightbulb (electrical energy to heat energy and light energy), a buzzer (electrical energy to sound energy), a wood-oxygen system (chemical energy to heat energy and light energy), a boy doing work (chemical energy to kinetic energy).

7. The student identifies the source of energy for a familiar system (animal, plant, car, electric appliance) and describes some of the energy conversions that take place in each system.

8. The student discusses events in the life of James Prescott Joule in relation to his scientific contributions and to the culture of his time.

15. Given several illustrated situations, some of which depict work being done and some of which do not, the student identifies those pictures in which work is being done.

20. The student identifies a fuel as a chemical substance that interacts with oxygen to release stored energy.

21. Given a description (written and illustrated) of a situation where several energy-converting systems have different amounts of fuel, the student identifies the system which can release the greatest amount of energy and orders the systems according to their capacity for releasing energy.

23. The student writes a short essay on how his life would be different if all the coal and petroleum on earth were used up.

27. Given data on a sample of water of mass m (in kilograms), at temperature t_1, and told that heat energy is added until the temperature is at t_2, the student determines the quantity of heat energy (in kilocalories) added to the sample.

29. The student identifies the following attributes of energy from the sun: keeps all the water in the oceans from freezing, makes the wind blow, is stored in petroleum and coal; is converted into sugars and starches by green plants, moves water from place to place on the earth's surface, and is the earth's most important source of energy.

30. The student writes a short essay on what his life would be like without the sun's energy.

Figure 2. Illustration of cognitive domain objectives concerning energy "Behavioral Objectives for the *Joule Unit*" (excerpt), from Champagne and Klopfer, 1975, pages 26-28.

AFFECTIVE OBJECTIVES

RECEIVING

The student is alert to everday situations where energy is being wasted

The student recognizes that her or his actions have an effect on the national consumption of energy.

RESPONDING

The student voluntarily seeks out information about ways to limit her or his personal consumption of energy

The student is willing to dress more warmly indoors in the winter in order to help limit family fuel consumption

VALUING

The student has a sense of responsibility for keeping the waste of energy in the home at a minimum

The student recognizes the desirability of using public transportation rather than a private automobile whenever possible.

The student assumes an active role in keeping the waste of energy in the home at a minimum by shutting off lights in unoccupied rooms

The student seeks out information about the cost benefits of limiting appliance use in order to influence her or his family to limit their energy consumption in this way

The student displays her or his conviction of the need to develop energy sources alternative to fossil fuels by encouraging elected representatives to support research on alternative energy sources.

The student displays her or his conviction of the need to reduce energy consumption by urging the family to keep the thermostat at the minimum level necessary for comfort in the winter

ORGANIZATION

The student relates her or his desire to own a large automobile to the need for conserving energy.

The student reexamines her or his preferences for certain kinds of architectural structures, in terms of whether they help or hinder energy conservation.

The student attempts to identify characteristics by which her or his family could develop a plan for limiting their consumption of energy.

The student judges candidates for elective office partly in terms of their commitment to alternative energy sources and the need to limit energy use

The student judges arguments by public figures about the feasibility of limiting energy consumption in terms of what she or he knows about the need to do so.

CHARACTERIZATION

The student is predisposed to consider ways of limiting energy consumption in making a decision about a house she or he will build or buy.

The student views her or his career choice in terms of her or his desire to seek ways to limit energy consumption or to seek energy sources alternative to fossil fuels.

Figure 3. Illustration of affective domain objectives concerning energy.

Content relating to information and knowledge must be considered from two standpoints, completeness and accuracy. Our current energy dilemma is highly complex, and even a superficial understanding of its complexities requires some knowledge in several of the academic disciplines. Some elementary knowledge of principles of physical, biological, social, economic, and political science is necessary for an appreciation of the complexity of the energy dilemma and for informed, sensible personal decisions about energy use. This suggests that the content of an effective program of energy education will be multidisciplinary. The effects of an energy education program that considers the energy dilemma from the perspective of a single academic discipline can be deleterious to the goal of attaining informed knowledge of the issues in energy use. Such perspective may suggest simplistic solutions to a complex problem, solutions that are not likely to be satisfactory.

Accuracy of informational content needs to be considered from two perspectives, the correctness and precision of the information, on the one hand, and the intellectual honesty with which it is presented, on the other. Checks on the correctness and precision of information can be made with relative ease by experts from the relevant academic disciplines. The perspective of intellectual honesty of informational content is more subtle. This criterion requires that students be made aware of the fact that some of the information presented is tentative and that in our complex world many decisions are made in the absence of complete information. It also requires that general principles with regard to energy conservation, rather than specific dictums, be taught. This distinction can be illustrated by an example from the health field. Some years ago the public was urged to have annual chest x-rays for the purpose of the early detection of tuberculosis. When the realization of the potential dangers of regular x-rays forced a change in this health policy, many people took the attitude that this was yet another example of the contradictory advice of the "experts," in this case the

physicians. If people had been taught the health principle behind annual x-rays--namely, that early detection of TB improves the prognosis--and then had been given alternative means for early diagnosis, the effects of changing recommendation would not have been as negative. Similarly, if students are taught general principles regarding energy education, rather than specific rules, they will be better able to cope with the vicissitudes of the energy situation that can be expected in the future.

The informational content of energy education programs will, if it meets the criteria suggested above, provide the basis on which decisions can be made and plans of action can be formulated. Providing information alone, however, does not insure that the student has the skills necessary to use this information to solve problems or to make decisions or plans. Thus, included as a part of the content of an effective energy education program should be opportunities for students to develop skills in decision making and problem solving. While the development of these skills is often included in statements of educational goals, there is evidence that they are given much less attention in schools than knowledge goals.[7] If energy education is to achieve its goals, the teaching of decision-making and problem-solving skills will need to be emphasized in the content.

If goals of an energy education program include having students apply decision-making and problem-solving behaviors to energy-related situations they encounter outside the school, the development of skills in values clarification and personal goal setting will also need to be included in the energy program's content. Students will conserve

[7]This appears to be true even in school subjects such as science and social studies where problem-solving goals are more highly touted than knowledge goals. For discussions of this issue in relation to science and social studies, see Champagne and Klopfer (1977) and Massialas and Cox (1966).

energy outside the school only when this action is consistent with their personal goals. Helping students clarify their values and understand the consequences of their goals is a very important aspect of energy education's content.

The foregoing discussion delineates some considerations we feel should be kept in mind in planning the content of energy-education instructional materials or programs or in judging such content. Table A-2 (Appendix A) presents a more detailed and specific list of questions that should be considered in judging the content of effective energy education materials. Figure B-1 (Appendix B) shows the science content as it is presented to the student in one set of instructional materials on energy, the Joule Unit.[8]

As a final note, we point out that our criteria have some interesting implications for our present system of formal education. To meet the criterion of multidisciplinarity of content, for example, formal education must be prepared to break down its traditional subject matter barriers. The inclusion of content in the areas of decision making, problem solving, goal setting, and values clarification also requires considerable departure from tradition. Thus, while we believe that formal education can provide individuals with the information, skills, and motivation needed to cope effectively with the current energy dilemma, we anticipate that effective energy education will require from schools a willingness to reorganize the usual compartmentalization of school subjects.

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[8] The Joule Unit (Champagne & Klopfer, 1974a) is an instructional unit on energy intended to be used by elementary and middle school students as part of a comprehensive science program. Materials from the Joule Unit are used here and in other places in this paper as illustrative examples of the application of some of our principles of instructional design.

Instructional Strategies and Materials

In our view, the goals of an energy education program necessarily cover a broad range of knowledge and behaviors of different levels of complexity. In order for these goals to be realized, they must be translated accurately into effective teaching procedures and instructional materials. The process of accurate translation, known as instructional design, is a complex one. Each of these aspects of instructional design--defining teaching procedures and developing instructional materials--will be considered in turn.

One important step in the definition of teaching procedures is the statement in behavioral terms of what is to be learned by the students. Once the desired outcomes for a program are stated and classified, a next step in the design process is to select an appropriate teaching procedure to bring about a desired outcome. Learning theory suggests that behaviors from different domains and behaviors of different levels of complexity are learned in different ways. For example, riding a bicycle (a higher level psychomotor behavior) and spelling cat (a lower level cognitive behavior) are both learned behaviors. Each is learned under very different conditions.

An instructional strategy is the process by which the conditions for learning a certain class of behaviors are created. For example, in cases where it is necessary to impart information to the student, a didactic instructional strategy may be used. Figure B-2 (Appendix B), a reproduction of Joule Lesson 5, in which information about types of energy conversion is presented to the student, illustrates the didactic instructional strategy. Other kinds of instructional strategies are used when it is desirable for the student to learn higher level cognitive behaviors. Joule MinEx 3, reproduced in Figure B-3 of Appendix B, illustrates the application of modeling to teach a problem-solving behavior. "A Seminar on Energy," part of which is reproduced in Figure B-4 (Appendix B), illustrates the use of simulation to teach students how to

behave when participating in a seminar. Modeling and simulation are instructional strategies sometimes used to teach complex behaviors.

There is a considerable body of research and psychological theory from which evolve principles that are useful in designing instructional strategies for successful teaching of behaviors from different domains and of different levels of complexity. An example of such a principle involves the relationship between experiences with physical objects and the learning of abstract concepts. Some psychologists believe that understanding of physical concepts is gained only after having had the opportunity to experience them through the manipulation of physical objects. This principle is illustrated in the excerpt from Joule Lesson 5 in Figure B-2 (Appendix B). In this lesson, the student experiences the concept of energy conversion through manipulations and observations of a battery-bulb-buzzer system. The student experiences firsthand the conversion from potential energy (the chemical energy stored in the battery) to kinetic energy (the light and heat from the bulb and the sound and the heat from the buzzer). The Joule MinEx 3 illustrated in Figure B-3 (Appendix B) is another illustration of the application of this principle.

Educators are most experienced in designing instructional strategies to successfully teach the lower level cognitive behaviors. The higher level cognitive behaviors represent a greater challenge. Designing instructional strategies that teach people to take action on the basis of what they have learned in energy education is a challenge of an altogether different order of magnitude.

It cannot be assumed that providing students with information about energy and the shortage of energy necessarily will have any effect on their actions with regard to energy consumption. Indeed, it has been the finding of educators in other fields where a goal of education is to change people's behaviors, e.g., nutrition, that providing people with information does not change their behaviors (see,

for example, Hochbaum, 1977). Behaviors related to energy consumption, like those related to eating, are, in general, habitual, requiring no deliberate attention from the individual. To achieve the goal of changing students' behaviors with respect to energy consumption, the instructional strategies of an energy education program must take this habitual nature of many of these behaviors into account.

As a first step toward changing these behaviors, students should be made aware of their habits of using energy, i.e., these behaviors must be brought into the realm of conscious attention and decision making. Further, instructional strategies should make provision for guiding students in the process of making responsible, informed decisions about their use of energy. And, just as it is true that a decision maker who must choose a program of energy education must make this decision on the basis of what is valued, so a student making a decision about his or her use of energy must also make this decision on the basis of what he or she values. This implies that the instructional strategies of an energy education program will need to be concerned with helping children identify and clarify their own values. This further implies that the student should not merely be asked to state his or her values with respect to energy, but also that ~~the~~ student be aided in the process of identifying and clarifying such goals.[9] Especially important in a program with the goal of changing students' behaviors or actions is the opportunity for students to set goals for themselves, on the basis of their own values. Goals are "indispensible for action" (Kreitler & Kreitler, 1976, p. 103) and are necessary links between beliefs and values, on the one hand, and actions, on the other.

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[9] Various techniques for values clarification have been devised, and some of the most interesting ones are discussed in Raths, Harmin, and Simon (1966).

The clarifying of values and the setting of goals can be viewed as prerequisites to an individual's changing his or her habits of energy consumption. Such a goal might be broad and altruistic; for example, "I would like to conserve energy for the sake of future generations." More relevant to the student and, therefore, probably more effective in changing the student's behavior would be a goal such as, "I would like to reduce my family's utility bills." In any case, having formulated a goal, the student can then go about the process of making responsible decisions about energy consumption.

The foregoing discussion suggests a number of questions to be considered in designing the instructional strategies of a program of energy education. We have listed a sampling of such questions in Table A-3 of Appendix A.

Not only must an instructional strategy be appropriate to the desired behavior, it must also be appropriate to the learner characteristics of the target population of students, and it must make adequate provision for the individual differences and needs of individual children. So, too, the instructional materials must be designed and produced to fit the learner characteristics of the target population and have built-in mechanisms for accommodating to different individuals' learner characteristics.

The questions in Table A-4 of Appendix A are included to provide a framework for consideration of issues relating to student instructional materials. Characteristics of the target population which can be predicted with a moderate degree of accuracy include level of reading ability, level of cognitive development, level of motor skill development, and achievement level in mathematics. Materials should be developed to match what is generally known about the level of development or achievement of each of these characteristics in the target population. However, even within a well-defined population, children will exhibit these characteristics to greater or lesser degrees. A

well-designed program will make provisions for these individual differences. As an example, we can cite the use of read-along audio tapes designed to accompany printed instructional materials. The printed materials are written for children who are reading at grade level. The audio tapes represent an accommodation to the individual needs of those children who are reading below grade level.

There are other ways in which children's learning requirements differ that are not predictable simply by knowing the characteristics of the population of which the student is a member. Students differ in the sensory mode by which they learn information best, some gaining more information from listening and others from reading or from TV or movies.

Children also exhibit preferences for different social settings for learning. Some prefer to learn by themselves, others are more satisfied learning by interacting with others--the teacher or their peers. An important point for consideration in any educational program is the extent to which accommodations for these and other differences are made in the instructional materials.[10]

There are both theoretical and technical considerations that should be given to the design and production of print media, illustrations, visuals, sound recordings, and films. The selection of these to fulfill specified instructional requirements should show the awareness and use on the part of designers of the research relating to their most effective use in teaching for specified outcomes.[11] Sections E,

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[10] The ideas expressed here relate to the notion of adaptive education. One comprehensive account of this notion may be found in Glaser (1977).

[11] Reviews of research in these areas have been undertaken from various points of view by educational theorists. See, for example, the reviews by Levie and Dickie (1973); Frase (1973); and Wittrock and Lumsdaine (1977).

F, and G of Table A-4 contain questions that pertain to the level of technical quality of the instructional materials. These questions focus on the issue of whether the materials have been produced carefully or whether slipshod techniques were used. Some specific questions listed in those sections of Table A-4 may appear to be extremely trifling. Nevertheless, in the aggregate, these questions are very important. Technical quality can either enhance or limit the effectiveness of instructional materials and the instructional strategies which are used in them.

The Teacher

The teacher is the single most important element in an educational endeavor. Without competent, committed teachers, even the best conceived and most carefully developed educational program cannot be successful. Provisions must be made in educational programs to provide teachers with adequate preparation for the task of implementing the program and for continued support during the implementation process.

The implementation of energy education programs will represent a challenge even to the most experienced and creative teacher. The multidisciplinary character of the energy dilemma and the need to provide experiences that will give students opportunities to define their personal goals, clarify values, and examine their behaviors combine to make energy education a major undertaking for the teacher. To experience success, the teacher must be committed to energy education, be knowledgeable in several academic disciplines, be able to integrate this knowledge and bring it to bear on the energy dilemma, and be competent to teach for complex skill attainment and positive attitude development. We can predict that, in large measure, the initial success of an energy program will be determined by the extent to which the teacher preparation program is successful in helping

teachers develop these attitudes and competencies. Section B of Table A-5 (Appendix A) contains some specific questions relating to the conceptualization of a teacher preparation program for energy education.

Section A of Table A-5 addresses several interrelated issues pertaining more directly to the teacher's personal role in an energy education program. The questions in Section A provide a framework for assessing the teacher's potential for experiencing success in an energy education program. The teacher's success will be determined in part by his or her own abilities and characteristics and in part by factors external to the teacher. Both the teacher and the situation in which he or she will be teaching should be carefully considered when selecting teachers for participation in a program. No amount of preparation or inservice support can overcome the deficiencies of a poorly trained teacher or the resistance of the reluctant teacher. Questions related to the personal characteristics of teachers can also be used as a basis for diagnosing the needs of teachers who are being prepared for teaching in energy education programs.

Other questions in Section A of Table A-5 examine factors external to the teacher which will impinge on the teacher and influence her or his success. Some of these factors include the administrative support the teacher can expect and the physical classroom facilities, equipment, and other services available to the teacher. Even a well-prepared and highly motivated teacher can become discouraged and experience failure in the face of a difficult teaching situation.

Another issue, one addressed by the questions in Section C of Table A-5, concerns the adequacy of the program's teacher materials to provide the teacher with continuing information and support during the implementation process. Teaching a new program requires the learning of much more information and the development of new teaching skills. More learning is required than can be absorbed in the time

usually allotted to teacher preparation programs. Therefore, much of the information presented during the teacher preparation program must be available to the teacher when she or he is back in the classroom. A well-designed manual containing carefully selected and written information can provide the teacher with ongoing support. For example, sufficient information on the subject-matter content should be provided to help the teacher feel confident that the necessary information is readily available to cover most classroom situations. Figure B-5 (Appendix B) shows an excerpt from the Joule Unit Science Content Overview. The purpose of the Science Content Overview is to provide the teacher with background information about the science content taught in the Joule Unit.

The personal characteristics of the teacher and the type of school situation in which he or she is to use an energy education program are among the strongest influences on the success of a thoroughly conceived program in the classroom. The teacher materials provided by an energy education program, however, will be vitally important in communicating to the teacher the attitudes, knowledge, and skills that are required in this new educational undertaking.

Student Assessment

[illegible] importance to the instructional strategies and ma- [illegible] ation program are the provisions the program [illegible] what students learn and how their out-of-school behaviors [illegible] designed instruction makes learning possible and provides opportunities [illegible] changes in students' behaviors to occur; well-designed assessment procedures increase the probability that students will acquire new knowledge and skills and that they will make use of the opportunities to develop new behaviors. Providing for the assessment of students' achievement or behavior in any aspect of an energy education program serves to focus the students' attention on that aspect--be it acquiring knowledge, learning problem-solving skills, clarifying values, developing attitudes, or making decisions. Aspects of the program in

which students are not assessed tend to be ignored by the students and viewed as unimportant. If, for example, the energy education program seeks to improve the students' capabilities in making decisions about conserving energy but only provides for assessment of their knowledge of information about energy, the chances for realizing the outcome of improved decision-making capabilities are greatly decreased. Student assessment, then, is a key factor in determining the extent to which students will attain the desired outcomes specified by the program.

Procedures and instruments for student assessment fall into the area of educational measurement and evaluation, about which a good deal is known as a result of several decades of reasearch and experience.[12] To provide for student assessment in an energy education program, it usually will not be necessary to invent something completely new. Rather, most of the needs for student assessment in energy education can be fulfilled by intelligently applying and adapting existing assessment procedures. Whether this has been done or will be done is an important question to raise about any particular extant or proposed energy education program. For a program that already has some provisions for student assessment, we would next inquire whether or not generally accepted assessment procedures and practices were employed.

Virtually all systematic assessment procedures begin with clear specifications of the objectives the student is to achieve. It is for this reason that, in the earlier section of this paper on goals and objectives, we insisted on the necessity of writing functional statements of objectives. The effort involved in making these statements as clear and precise as

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[12] The many years of work in educational measurement and evaluation have produced countless assessment instruments and a vast number of papers and books about student assessment procedures. For us, the two most useful compendia on student assessment are Bloom, Hastings, and Madaus (1971) and Thorndike (1971). However, educational measurement and evaluation is a very busy area, so the current periodical literature also must be consulted to keep abreast of new student assessment procedures.

possible is worthwhile because they constitute the basis for designing appropriate assessment procedures, and that task becomes much easier when there is a minimum of ambiguity about the learning and behavioral outcomes expected of students as a result of their experiences in the program. The statements of objectives should cover the full range of expected outcomes so that, taken all together, they can be used to define the total population of student learnings and behaviors which will be sampled by means of the assessment procedures. It is patently impossible to assess students on each and every desired outcome that an energy education program specifies, but it also is essential that no crucial or highly valued outcome goes unassessed. Hence, another key question about the adequacy of the assessment procedures concerns the extent to which the sampling of student learnings and behaviors which actually are assessed is balanced and represents the total population of desired outcomes. In Table A-6 of Appendix A, we have listed a number of additional questions that should be considered in judging the adequacy of student assessment procedures of an energy education program.

Two cautions must be kept in mind when confronting the matter of student assessment in energy education. First, student assessment is almost certain to be incomplete and inadequate if it deals only with learnings in the cognitive domain. The temptation to do this is strong because assessment procedures and instruments are presently most fully developed in the cognitive domain and because educators are most familiar with assessing cognitive learning, and it seems safe. However, as we have argued throughout this paper, cognitive learning is merely one component of energy education. At least as important, and probably more so, are the development of problem-solving skills, clarification of values, improving capabilities in decision making, and developing appropriate out-of-school behaviors with respect to energy conservation. Student learnings and behaviors in these aspects of energy education must also be assessed. Admittedly, procedures for such assessments are not so well developed as in the cognitive domain and

a little more imagination and effort are required to carry them out. But, these are insufficient grounds for omitting student assessment in crucial aspects of energy education.

The second caution is to avoid reliance on student self-assessment as the sole assessment procedure where important aspects of energy education are concerned. All too often in instances when setting up a more systematic assessment procedure is difficult, cumbersome, or expensive, attempts at assessment are abandoned or students are asked to assess their own learning and behavior. Self-assessment alone is insufficient, however. We do believe that self-assessment of one's own learning is the best and ideal kind, in contrast with assessments externally imposed on individuals. In fact, we have been party to an instructional program that has as a goal the development of the ability to assess one's own learning in straightforward and clearly defined situations.[13] But we also know that successful self-assessment involves specific skills that must be learned over a considerable period of time. Very few students have opportunities to learn these skills in schools today, so that very few are able to assess their own learning. This is true especially for situations where the learning or behavior is complex and the assessment criteria are ill-defined. These characteristics describe, it seems to us, many of the important desired outcomes of energy education, and we are not hopeful that self-assessment will be a highly successful assessment procedure with respect to them. We are not recommending that self-assessment should not be used, but we do urge that it should not be

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[13] A brief discussion of the goal of student self-assessment in the Individualized Science program is contained in Champagne and Klopfer (1974c), and specific illustrations of self-assessment procedures may be found in Champagne and Klopfer (1975). Evidence about how well students can assess their own learning is presented in the research study by Walker (1975).

relied upon as the only procedure. Here, as with other issues related to student assessment, good sense guided by reliable knowledge must prevail over expediency if an energy education program is to have the best chance for being effective.

Implementation

We have addressed in some detail the philosophical and theoretical issues that must be considered in designing an energy education program. The decisions that are made about these aspects of the program and the success with which these decisions are translated into classroom procedures and materials for the teacher and students represent one factor that will determine the extent to which the program is adopted for use in schools. Education is not, however, all theory and philosophy. The adoption and success of a program depend also on economic and practical considerations. The cost and the ease of implementation of a program, both at the school and classroom levels, are factors of major importance to school administrators and teachers.

A program with high initial or replacement costs or a program that makes excessive demands on school resources (classroom or storage space, time for teacher preparation, for example) is not likely to be adopted by the school. Questions that should be asked about both immediate direct costs and long-term indirect costs of a program are posed in Section B of Table A-7 (Appendix A).

A program that is difficult for the teacher to implement will not be used. The packaging of a program must be designed so that it is convenient for teachers and students to use. Section A of Table A-7 addresses some very pragmatic issues that influence the ease of implementation of a program. Consideration of these issues in the process of disguising a program can reduce the probability that the program will later have problems in adoption or implementation.

Program Evaluation

In the preceding sections of this paper, we have delineated a large variety of considerations about energy education that influence the effectiveness and success of an energy education program in schools. Questions about a program's rationale, goals, and objectives, its content and instructional strategies, and its provisions for the teacher, for student assessment, and for implementation represent considerations about the internal qualities of an existing or proposed program. In this section and the next, we turn to considerations external to an energy education program that are pertinent to making decisions about its actual or potential value.

Persons who are responsible today for making decisions about educational programs are fortunate. Unlike in the past when such decisions had to be made primarily on the basis of testimonial evidence and fortuitous observations, there is today an active area of evaluation research in education, one of whose primary purposes is to provide reliable information to educational decision makers about how well educational programs "work."[14] This is not the place for us to give a short course on the techniques and procedures used in program evaluation research, but we can point out that the findings from evaluation research represent the kinds of evidence that can serve as the basis for decisions about the value of a program. While program evaluation research findings are not the only evidence that a decision maker should consider, she or he is fortunate to have them available.

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[14] To anyone seeking more information in the area of evaluation research, we heartily recommend an excellent discussion on the philosophy and methodology of educational evaluation in Cooley and Lohnes (1976).

Several kinds of evidence should be provided in the findings from an evaluation of an energy education program. First of all, there should be evidence about the extent to which the program's goals are achieved when it is used in schools. It is important that this evidence attends to all of the program's goals, not only to those that concern cognitive learning or those that are easy to test for. Our remarks on this score in the earlier section on student assessment pertain here also. There also should be evidence about the appropriateness of a program for the target population of students for whom it is intended. Similarly, there should be evidence about the appropriateness of the program for the target population of communities where it is intended to be used. In Table A-8 (Appendix A), we have listed a number of questions that suggest the various kinds of evidence that educational decision makers could expect to obtain from the evaluation of an energy education program.

Quite a number of factors affect the adequacy of the evidence that is reported in program evaluation research. One important factor is whether the reported evidence comes from a formative evaluation or from a summative evaluation of the program. We have written elsewhere (Champagne & Klopfer, 1974b) about the stages of and procedures for formative evaluations, which are conducted while the instructional materials of a program are in the process of development. Instructional materials generally are revised, sometimes radically, on the basis of formative evaluation findings, and such revisions may be made several times before the final version of the program's materials is produced. Summative evaluations are carried out when the final version of the program has been released to the general public. The point to be emphasized is this: Reported evidence based on a formative evaluation of a program cannot be unequivocably accepted as evidence about the quality of the program's final, publicly released version. The reason is that the instructional

materials in the publicly released version may be quite different from those used at the time of the formative evaluation. When a research report is not clear about the basis of its evidence on either a formative or summative evaluation, the reported evidence is inadequate. Other factors that can contribute to the inadequacy of reported evidence are suggested by the questions we have listed in the second section of Table A-8. Educational decision makers should be aware of these factors; yet, if the caveats are heeded, evidence reported from program evaluation research can play an important role in making decisions about the value of an energy education program.

Although we believe that evidence from program evaluation research can be very valuable in making decisions about the value of an energy education program, we do not take the position that research evidence is all that decision makers ought to consider, especially when they are deciding whether or not to select a certain program for use in a school. Important aspects of decision making in this situation are to determine the extent to which the program's assumptions are consistent with the beliefs of the people in the community where it is to be implemented and to consider carefully the implications of implementing an energy education program in a community where its assumptions and the community's beliefs are incongruent. If, for example, a program is based on the assumption that governmental control of an individual's energy consumption is right and proper, it can be assumed that the program will meet with some form of opposition in a politically conservative community. More liberal communities might find unacceptable any program that does not explicitly state the assumptions on which it is based or fails to give the learner the opportunity to examine critically each of the assumptions. On the other hand, communities dedicated to energy conservation might not require that a program adopted for their schools critically evaluate assumptions that are consistent with the community's belief in energy conservation. The

possible situations we have illustrated here call attention to the fact that making decisions about selecting an energy education program for implementation in schools is not a straightforward matter. Where decisions have to be made, values are involved.

Designer and Development Team Qualifications

Our experiences and the experiences of others concerned with the design, development, analysis, and implementation of educational programs bear witness to the observation that the quality of any program that is produced strongly depends on the qualifications of the people who produce it. This observation is significant for making decisions about the value of an existing energy education program or the potential value of a proposed program. The chances of producing a superior program are greatly enhanced when well-qualified people are involved.

In Table A-9 of Appendix A, we list some key questions concerning the qualifications of the designers and development team of a program in energy education. We are convinced that the requirements for effective energy education are so diverse and complex that a multi-talented team is needed to develop a good program, and this belief is reflected in our questions. We also are wary of external trappings of respectability or slick veneers, but prefer to look for evidence of substantial accomplishments, relevant experiences, and creativity. And, in addition to the personal qualifications of people, the support provided by the institution or organization which surrounds them is an essential component of designer qualifications.

Our consideration of designer qualifications might more appropriately have been placed near the beginning of this paper than at the end, for we firmly believe that the commitment of competent people and capable institutions is the single most important ingredient that is likely to make a difference in whether or not there will be effective

energy education in schools. It is our hope that the ideas and suggestions we have given here will be useful to the singularly important men and women who are concerned with energy education and will help you take appropriate next steps.[15]

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[15] We are grateful to Joan Donnelly and Dorothy Molter for their contributions in conceptualizing and preparing drafts for parts of this paper. Without their help, the paper would have been something much less, both in scope and detail. We also want to thank Alexandra Antoniewicz, Christine Frezza, and David Squires for editorial and clerical assistance in preparing the paper.

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APPENDIX A

Tables A-1 through A-9

Table A-1

Rationale, Goals, and Objectives

A. Adequacy of Rationale

1. Is there a rationale for the program, or must the rationale be inferred from the program's instructional materials and procedures?

2. Is the program's rationale conceptually sound?

3. Are the assumptions that underlie the program's rationale clearly set forth in the rationale?

4. Which philosophical assumptions underlie the program's rationale? For example: Do the program's developers believe that educators in schools have the right or responsibility to teach directly for changes in students' out-of-school behaviors? Do they believe that individuals have a right to consume as much energy as they please and can afford to pay for?

5. Which psychological assumptions underlie the program's rationale? For example: Do the program's developers believe that it is possible in the context of formal education to teach children to change their out-of-school energy conserving behaviors?

6. Which assumptions about social policy underlie the program's rationale? For example: What do the program's developers believe about the extent to which formal education should act as an active agent of social change by teaching individuals ways to adjust their life-styles in the face of energy shortages?

7. Which political assumptions underlie the program's rationale? For example: What do the program's developers believe about how much control the federal government can exert over the energy consumption of individuals and businesses?

8. Which scientific assumptions underlie the program's rationale? For example: Do the program's developers view the conversion of solar energy as an important source of energy for power generation? What is the developers' stance with regard to the safety of nuclear energy sources?

9. Which economic assumptions underlie the program's rationale? For example: Do the program's developers believe that the cost of energy to individual consumers should be kept reasonably low?

10. Does the rationale include any unwarranted assumptions or uncritically accept any untested assumptions?

11. Are the assumptions underlying the program's rationale consistent with those held by individuals in the communities where the program will be used? If they are not, what are the implications of the discontinuity?

12. Are the assumptions underlying the program's rationale made explicit to the learner through the program's instructional materials?

B. Conceptualization of the Program

1. Are there explicitly stated goals, or must the goals be inferred from the program's instructional materials and procedures?

2. Are the goals of the program consistent with its rationale?

3. Are goals included which attend to the teaching of information, the development of problem-solving skills, and techniques of personal values clarification, decision making, and goal setting?

4. Do the goals include engendering out-of-school behavior changes in students, or are all goals stated only in terms of behaviors related to the formal educational setting?

5. Are the goals appropriate for the target population of students who use the program?

6. To what extent are the goals acceptable to the greater society and to special interest groups concerned with energy?

7. Are the goals stated with sufficient specificity to test the congruence between the program's goals and the instructional strategies it employs?

8. Are there ways for assessing how well the goals of the energy education program have been achieved?

9. Are there explicitly stated objectives corresponding to all the program's goals?

10. Are the objectives consistent with the program's rationale and goals?

11. Which levels of student behaviors in the affective domain are represented in the program's objectives?

12. Which levels of student behaviors in the cognitive domain are represented in the program's objectives?

13. Are the objectives stated in behavioral terms or in some other way that makes them functional?

14. Do the objectives clearly communicate the developers' intent to the teachers who will implement the program?

15. Can the objectives be used by the teacher to assess the extent to which the program's intended effects have been engendered in the students?

16. How well integrated are the instructional components of the program?

17. Are there provisions for monitoring the progress of students and assessing their attainment of objectives in the program?

18. What evidence is there that the design of the program takes into account the findings of educational and psychological research?

C. Planning for a Proposed New Program

1. What is unique about the proposed energy education program?

2. Is there an overall plan for the design and development of the proposed program?

3. Is the plan for developing the proposed program feasible?

4. Is a strategy built into the development plan for modifying it if necessary?

5. Are the program's goal statements sufficiently specific to guide the development of instructional strategies and materials that match the goals?

6. Does the development plan include a mechanism for formative evaluation?

7. Is the plan for the design of the proposed program sufficiently thorough and internally consistent?

8. Does the plan for the design of the proposed program take into account the known characteristics of the students who will use it?

9. Does the plan consciously or unconsciously violate generally accepted tenets of developmental theory or of cognitive learning theory?

10. What means are suggested in the planned design of the proposed program for evaluating student achievement and assessing changes in out-of-school behaviors?

Table A-1 (Continued)

11. What roles and expectations for the teacher are planned in the design of the proposed program?

12. Does the planned design of the program give sufficient attention to the management of the proposed program in the classroom?

13. Are the limitations in finances, flexibility, and adaptability of schools recognized in the plan for the proposed program?

Table A-2

Content

A. Coverage

1. From which of the academic disciplines is the program's subject matter drawn?

2. Is any essential subject matter missing from the program's content?

3. Is more subject matter from any academic discipline included in the program's content than is necessary to meet the program's goals?

4. Are the breadth and depth of subject-matter content adequate to meet the program's goals?

5. Is information concerning the consequences--personal, short-term, social, long-term--of current habits of energy consumption provided to the student?

6. Is information about alternatives to current habits of energy consumption provided?

7. Is there a good balance between subject matter and process skills content?

8. Which skills are included as a part of the program's content?

9. Is the range of skills included in the program's content sufficient to meet the program's goals?

10. Does the program's content include the process skills necessary for making decisions and solving problems about energy use which the student may expect to face?

11. Does the program's content include the skills the student will need to attain the goals of clarifying one's values, setting personal goals, and solving problems in regard to one's personal energy consumption?

12. Is the student provided with suggestions and guidance for obtaining the information needed to attain his or her goals with respect to energy consumption?

13. Does the program's content help the learner to distinguish between emotional and logical arguments relative to the energy dilemma?

14. Does the program's content help the learner to distinguish between reliable sources of information concerning energy and sources that may be biased?

B. Appropriateness

1. Is the subject matter and process skills content of the program well matched to the needs and abilities of the target learner population?
2. Is there evidence that the content of the program is appropriate for the range of levels of cognitive development likely to be encountered in the target learner population?
3. Are the skills presented in the program relating to values clarification, goal setting, and problem solving appropriate to the range of levels of affective development likely to be found in the target learner population?
4. Is subject-matter content sufficient to provide an adequate understanding of issues relevant to the energy dilemma which individuals in the target learner population may encounter?
5. Are the principles of energy conservation presented in the program widely applicable to the range of energy use patterns likely to be encountered by the target learner population?
6. Is the program's content likely to be interesting and informative for the individuals in the target learner population?
7. Is there a good match between the program's subject matter and the process skills it attempts to teach? That is, is the subject matter a good vehicle for teaching the process skills?
8. What values are expressed in the selection of the content of the program?
9. Does the program present well-established principles of energy conservation rather than emphasizing a set of prescriptive rules that may become obsolete or outmoded?
10. On what basis has the subject-matter content of the program been selected?
11. On what basis was the process-skill content of the program selected?
12. Is the portion of the content relating to values clarification, goal setting, and problem-solving skills given sufficient emphasis compared with the emphasis given to the subject-matter portion of the content?

13. Which values are emphasized in the program's content?

14. Does the program's content overemphasize a certain viewpoint or belief to the extent of virtually excluding equally valid alternative viewpoints or beliefs?

15. Is the reasoning in the arguments the program presents concerning the energy dilemma always logically sound?

C. <u>Accuracy of Subject-Matter Content</u>

1. Are the information, concepts, principles, theories, and speculations included in the subject-matter content consistent with accepted ideas in the relevant academic disciplines?

2. What evidence is there that the program's subject-matter content has been reviewed for accuracy?

3. Are the technical terms drawn from the academic disciplines and included in the program's subject-matter content defined with sufficient care so that their meaning is unambiguous and clear?

4. When a concept which is included in the subject-matter content has both a popular and a technical meaning (e.g., work), is the necessary distinction clearly made?

5. Does the program's content help the learner to distinguish between broadly applicable principles of energy conservation and narrow prescriptive rules?

6. Has the subject-matter content been presented in such a way as to correctly distinguish fact from theory and/or speculation?

7. Are any assumptions which are presented in the subject-matter content identified as assumptions?

8. Does the learner have the opportunity to question any assumptions which are set forth, or are they to be accepted without examination?

9. Are those well-established concepts and principles which are included in the subject-matter content identified as ideas which are not likely to be changed over time and on which the learner can rely?

10. Where the subject-matter content includes information that is not yet well established, are cautions given that the information is subject to change?

11. Are ideas which are supported only by limited evidence at the present time identified as tentatively held ideas?

Table A-2 (Continued)

12. Does the program's content help the learner to distinguish between tentative and well-established ideas?

Table A-3

Instructional Strategies

1. Are the instructional strategies well matched to the learnings?
2. Is provision made for students to examine their own habits of energy consumption?
3. Are opportunities provided for the student to examine his or her own beliefs and values with respect to energy consumption?
4. Are techniques for setting personal goals with respect to energy consumption suggested to the student?
5. Are means of evaluating the consequences of his or her own goals with respect to energy consumption provided to the student?
6. Is the student provided with the information needed to plan ways of achieving his or her own goals with respect to energy consumption?
7. Is the student provided with strategies for selecting or planning ways of attaining his or her goals?
8. Is the student provided with means of evaluating the attainment of his or her goals?
9. Which principles of learning theory are applied in the instructional strategies of the program?
10. Is the process of reaching desired outcomes consistent with the instructional strategies?
11. Which instructional strategies are used to enable the students to acquire a functional understanding of concepts, principles, and theories?
12. Does the program include appropriate instructional strategies that enable the students to develop skills in problem solving?
13. Is a sufficient variety of instructional strategies used in the program?

Table A-4

Instructional Materials

A. Adaptability to Learner Characteristics

1. Is the content to be learned appropriate to the ability and cognitive developmental level of the target population of students?

2. Are the skills to be taught appropriate to abilities and cognitive developmental level of the target population of students?

3. Do the instructional materials make realistic, rather than unrealistic, demands on the students' cognitive or manipulative skills?

4. How are the students' interest and active involvement with the instructional materials maintained?

5. Are the instructional materials selected or designed in such a way as to be adaptive to a variety of learner sensory modes?

6. Are illustrations and/or photographs appropriate for the developmental level of the student and for the kinds of pictorial information conveyed?

7. Are the design, format, artwork, and style of presentation likely to be appealing to students of the age level and environment for which the materials are intended?

B. Instructional Design Characteristics

1. What is the relationship between the stated instructional outcomes and the instructional materials?

2. Is the design of instructional strategies consistent with what is known about learning?

3. What attempts are made to share the objectives of the program with the student via the instructional materials?

4. Are the instructional materials adequate to enable the student to attain the instructional objectives?

5. Do the instructional materials provide the student with opportunity to practice the skills and behaviors of the program's stated outcomes?

6. Is provision made in the instructional materials to provide the student with adequate feedback on his or her performance?

7. Are the media of the various instructional materials appropriate for the kinds of information they are intended to convey? For example, is auditory information presented aurally; have appropriate media been chosen to present various kinds of visual information?

8. Are instructions to the student within the instructional materials clear and easily understood?

C. Sequencing

1. Is the sequencing of the instruction clear and based on some readily definable theoretical model?

2. Is the sequencing of instruction appropriate for the kind of learning (e.g., process, cognitive) the instructional materials are designed to teach?

3. Does the introduction to instruction begin with an experience or concept that is likely to be a part of the student's experience?

4. Does the introduction to instruction refer back to previous instruction in the sequence?

5. Are there adequate directions for the student to follow in proceeding from one part of the instructional materials to another part?

6. What kind of provision is made for assessing the students' performance during and at the end of the instructional sequence?

7. Is there an adequate summary in each of the instructional materials and a hint to the student of what will come next in the instruction?

D. Consistency, Accuracy, and Values

1. Are the facts, information, and interpretations of ideas included in the instructional materials correct or in accordance with the best current thinking on the topic?

2. Are the several components of the instructional materials free from inconsistencies (e.g., between directions for using manipulatives and the manipulatives themselves; between manipulatives and printed materials)?

3. Is the "tone" of the instructional materials consistent with the goals of the program (e.g., Are instructional materials designed to persuade the student to adopt a set of behaviors regarding energy use free from a tone that deprecates the student)?

4. Are the instructional materials free from obvious or subtle sexual, social, or racial bias?

5. From what moral and/or political perspective are values presented in the instructional materials?

6. Is information related to values presented honestly and realistically rather than overstated in an attempt to persuade the student of the "correctness" of a particular position?

7. Are the values expressed directly or indirectly in the instructional materials identified as such to the learner?

8. Are materials free from evidence of supporting the policies of any special interest group?

9. What affective outcomes are the instructional materials likely to produce in the student?

E. Printed Instructional Materials

1. Is the print medium appropriate for the behaviors being taught?

2. Is the reading level appropriate for students in the target population with respect to vocabulary, organization of ideas, and structure of sentences?

3. What provisions are made for students whose reading level is below the grade level for which the materials are intended?

4. Are the illustrations, tables, and/or photographs instructive and appropriate to the text and labeled properly and clearly? Do they convey accurate information?

5. Is the layout of the printed page attractive, easy to read, and instructionally functional (e.g., an illustration placed near text that refers to it)?

6. Are the printed typefaces clear, easy to read, and large enough for the students who will use the instructional materials?

F. Non-Print Media

1. Is the medium selected the most appropriate one for attaining the expected student behaviors and for presenting the topic being taught?

2. Is the medium selected the least expensive one that can adequately present the topic or concept?

3. Is the audiotape or recording of sufficiently good technical quality?

4. Is the language level of the narration in the audiotape or recording appropriate for the students in the target population?

5. Are the voices used in the audiotape or recording generally pleasant and distinct?

6. Do the sound effects used in the audiotape or recording support and enhance the narration?

7. If music is used in the audiotape or recording, is it properly "mixed" with the narration?

8. Is the pacing of the audiotape or recording satisfactory for students in the target population?

9. Does the audiotape or recording continue to produce sound of good quality after extensive use?

10. Are the visuals of the film, filmstrip, filmloop, or videotape technically well done?

11. Is the pacing of the film, filmstrip, filmloop, or videotape appropriate for students in the target population?

12. Do the visuals used in the film, filmstrip, filmloop, or videotape relate well to the accompanying audio portion?

13. Do the visuals in the film, filmstrip, filmloop, or videotape communicate the concept they are depicting (e.g., art depicting speed should convey the notion of motion)?

G. Manipulatives

1. Can most students in the target population (successfully) use the manipulative to carry out the program's specified operations with it?

2. Have the manipulative materials been selected and/or designed in accordance with what research has shown to be appropriate for the manipulative abilities of the target population?

3. Does the design of the manipulative enhance the possibility of its proper use?

4. Is the manipulative or apparatus designed so that it is self-instructional?

5. Are the sensitivity and accuracy of the apparatus adequate for the uses to which it will be put?

6. Does the manipulative have potential for general use in the classroom?

7. What is the life expectancy of the manipulative or apparatus in normal use?

8. Are manipulatives sufficiently sturdy to resist damage when dropped?

9. Are manipulatives made from non-toxic, flame-resistant materials?

10. Are manipulatives free from potentially dangerous sharp and pointed edges?

11. Is the manipulative or apparatus the least expensive one available that will function adequately?

12. If the manipulative is designed especially for the program, is there an essentially equivalent one commercially available that will function adequately?

Table A-5

The Teacher

A. <u>The Teacher and Energy Education</u>

1. How familiar is the teacher with the subject matter content?

2. How well can the teacher apply her or his knowledge of the particular concepts, principles, and theories included in the program to new or unfamiliar situations in everyday life?

3. What is the teacher's attitude toward energy education?

4. What does the teacher believe about the value of energy education in contemporary culture?

5. Does the teacher enjoy learning about energy education and keeping abreast of current developments in it?

6. Is the teacher capable of providing the instruction necessary to teach the complex skills that are defined as outcomes for the program?

7. Does the teacher possess the necessary manual skills to assemble and use the equipment and apparatus of the program and to perform the included laboratory procedures?

8. Is the teacher able to conceptualize, arrange, and successfully carry out the investigations and laboratory experimental exercises included in the program?

9. How good is the match between the teacher's personal philosophy of education and the philosophy, goals, and specifications for the classroom environment?

10. Is the teacher reasonably well convinced that her or his students can perform well in the program and that they will like it?

11. Is there any part or component of the program with which the teacher disagrees or feels she or he does not understand well enough?

12. Does the teacher feel confident that she or he can organize, arrange, and adapt the furnishings, equipment, and other physical features of her or his classroom into a viable learning environment for the program?

13. Are there adequate directions to the teacher for assembling, preparing, setting up, and using the manipulative materials and equipment?

14. Is the teacher secure about her or his school's administrative support for her or his use of the program?

15. Does the teacher perceive that the teacher preparation program has been adequate for her or his needs in using the energy education program?

16. Does the teacher think that the program's teacher instructional materials give her or him a sufficient orientation to operate the program in the classroom?

17. Does the teacher think that the program stifles her or his own initiative and creativity to an intolerable degree?

B. Teacher Preparation for the Energy Education Program

1. Are the rationale and organization of the teacher preparation program consistent with the goals of the energy education program?

2. Are the teacher instructional materials and other instructional means and techniques used in the teacher preparation program appropriate for attaining the objectives of the teacher preparation program?

3. Is sufficient instruction provided in the teacher preparation program for the teachers to acquire confidence in performing the management and procedural tasks required by the energy education program?

4. Has the essential background knowledge that teachers need to operate successfully with the program been identified and made known to the teachers?

5. Are there adequate means and mechanisms included in the teacher preparation program for remediating any deficiencies between the teachers' assessed competencies and the essential information needed to operate successfully with the program?

6. Is the atmosphere prevailing in the teacher preparation program congruent with the atmosphere of the classroom learning environment espoused by the energy education program?

7. Does the teacher preparation program offer the teachers sufficient opportunities to work with all the various student materials of the energy education program?

8. How well does the teacher preparation program provide for the evaluation of the teachers' learning about the energy education program during the course of the preparation program?

9. Is the teacher preparation program successful in conveying to the teachers the "spirit" of the energy education program?

10. Do the teachers demonstrate a favorable attitude toward the energy education program before and after the teacher preparation program?

C. Materials for Teachers

1. Do the contents of the teacher materials give a fair and consistent representation of the program's philosophy, goals, organization, and content?
2. Are the media (print, non-print, manipulatives) of the teacher materials appropriate for the objectives they are intended to achieve?
3. Is the "tone" of the teacher materials consistent with the philosophy and goals of the program?
4. Is there a clear and rational organization in the teacher materials?
5. Are there adequate directions for how to proceed from one part of the teacher materials to the next part?
6. Do the teacher materials include sufficient provisions for sharing the objectives of the instruction with the teacher using the materials?
7. Are the provisions made in the teacher materials to give feedback to the teacher using them on her or his progress in attaining the objectives of the instruction?
8. What provisions are made for maintaining the teacher's utilization of the teacher materials?
9. Is the information contained in the teacher materials correct?
10. Are the illustrations, tables, and diagrams instructive and correctly matched to the text in printed teacher materials?
11. Are the art work, photographs, and page designs of printed teacher materials attractive and appropriate?

Table A-6

Student Assessment

A. Adequacy of Provisions for Assessing Desired Outcomes

1. Has a comprehensive list of desired student learning and behavioral outcomes been prepared?

2. What provisions have been made for assessing students' out-of-school behaviors as well as their in-school learnings?

3. Is there good correspondence between the program's specified outcomes and its student assessment procedures?

4. Is a reasonable proportion of all the desired learning and behavioral outcomes sampled by the assessment instruments and procedures used in the program?

5. Are the most valued learning and behavioral outcomes adequately assessed?

6. Do the assessment procedures make provision for testing relevant behaviors in all three domains (cognitive, affective, and psychomotor)?

7. Is there an overemphasis on the assessment of lower level behaviors in the cognitive domain?

8. Is there an overemphasis on the assessment of expressed attitudes?

9. Are students assessed on their ability to clarify their values and set goals with respect to energy consumption?

10. Are students assessed on their ability to apply their in-school learning about energy to out-of-school actions that decrease energy consumption?

B. Characteristics of the Assessment Procedures

1. Is the balance between assessment of students and self-assessment by the students a reasonable one?

2. What is the evidence that the program's developers are familiar with standard procedures and current practices in the area of educational measurement and evaluation?

3. Is excessive use made of traditional procedures for student assessment?

4. Are traditional assessment procedures applied intelligently?

5. Which innovative student assessment procedures are used?

6. Are the innovative assessment procedures used intelligently?
7. Do the student assessment procedures directly measure behaviors described by the objectives or are indirect measures used?
8. Where indirect measures are used to assess certain behaviors, are the measures valid?
9. Is the reliability of instruments used for student assessment satisfactory?
10. Have the items included in assessment instruments been carefully and correctly constructed?
11. Are the items included in assessment instruments free of racial, cultural, and sex-role biases?
12. How is the teacher involved in the student assessment procedures beyond the usual administration and scoring of paper and pencil tests?
13. How is information gained from student assessment procedures fed back into the instructional system?
14. Is a sufficient variety of procedures used to assess students?

C. The Student and Assessment

1. Do the assessment procedures serve as a positive learning experience for the student?
2. Will the student find that engaging in the assessment procedures is interesting, challenging, and satisfying?
3. Is the amount of student time devoted to assessment procedures excessive?
4. Is sufficient time allotted in the assessment procedures to make an adequate assessment of the student?
5. Do the students have the opportunity to learn to engage in and practice self-assessment?

Table A-7

Implementation

A. Packaging and Convenience (Implementation at the Classroom Level)

1. Is the packaging of the program's instructional materials adequate for efficient classroom use?

2. Is the labeling of packages of materials and the various components of the program clear and unambiguous?

3. Are provisions made to facilitate returning items that have strayed to their proper places?

4. Are the program's instructional materials packaged and designed adequately for students to work with them on their own?

5. Are sufficient quantities of all items needed to operate the program supplied?

6. Is it easy to obtain those items needed to operate the program that are not supplied?

7. Can the program's instructional materials be readily and efficiently stored?

8. Is it easy to organize the program's instructional materials so that they will be accessible to the students and teacher when needed?

9. Is the teacher easily able to do the chores necessary to put the program into operation and to maintain it?

10. Can the materials of the program be easily handled and moved from place to place?

11. Are the manipulatives free of manufacturing defects that can cause difficulties in their use?

12. Is it a relatively simple procedure to obtain replacements of materials and expendable supplies?

B. Cost Considerations (Implementation at the School Level)

1. What is the purchase price of all the components of the program that are needed to install it initially?

2. What amounts of consumable supplies and printed materials are necessary for the program's operation?

3. What is the purchase price of all program components needed to maintain the program from year to year after it has been installed?

Table A-7 (Continued)

4. How does the annual per pupil cost for this program compare with the annual per pupil cost for others that are available?
5. To minimize the expense of duplication, can the program materials be readily transported for sharing between classrooms?
6. Will installation of the program require the construction of new facilities or modification of existing facilities?
7. What are the personnel costs for workshops and other sessions that are necessary to prepare teachers to use the program?
8. Will it be necessary to employ additional teachers or other personnel to put the program into operation?
9. Does the teacher preparation program for the program require unusual facilities or equipment?

Table A-8

Program Evaluation

A. Evidence of Achievement of Program Goals

1. Does the student learn by engaging in the activities of the program?
2. How well does the student learn what the program developers intended him or her to learn?
3. How can the program be improved so that the student will learn better?
4. Does the student learn things from the program other than or more than what the developers intended he or she would learn?
5. Upon completion of his or her interaction with the program, does the student demonstrate new behaviors?
6. Upon completion of his or her interaction with the program, does the student demonstrate the behaviors that the materials purport to teach?
7. Does the student interact in the program in a way that is congruent with behaviors described by the program?
8. For any instructional unit, do students demonstrate mastery on paper and pencil tests after having studied the unit?
9. Do students reach the level of competency in out-of-school energy-related behaviors that are aimed for in the program?
10. To what extent do students attain the knowledge of facts, concepts, principles, and theories specified by the program?
11. To what extent do students comprehend the program's subject matter?
12. How well can students apply their knowledge of concepts, principles, and theories taught in the program to new or unfamiliar situations related to the energy dilemma?
13. How well can students apply their knowledge of concepts, principles, and theories taught in the program to situations in their daily lives?
14. How well do students integrate or synthesize specific content taught in the program with other knowledge they already possess?
15. Do students generate new ideas of their own based on their knowledge of particular concepts, principles, or theories taught in the program?
16. Do students apply rational decision-making procedures to energy-related problems?
17. How frequently do the students voluntarily participate in activities related to the energy dilemma?

Table A-8 (Continued)

18. Do the students develop the necessary manual skills to use the equipment specified by the program?

B. Evidence of Appropriateness of the Program for the Target Population

1. For any instructional unit, do pretest data show that most students in the target population are not already in possession of behaviors the unit will teach?

2. For any instructional unit, are the expected student behaviors generally too simple or too difficult for the students in the target population?

3. Does the student enjoy his or her interactions with the instructional materials?

4. Does the student dislike studying any of the instructional materials?

5. Do students show preferences for any particular type of learning procedure or instructional medium?

6. Does the student feel that what she or he is learning is worthwhile and/or relevant?

7. Does the student feel that what is presented is incongruent with his or her beliefs or values in any way?

8. Is there any lesson, activity, or procedure in the program that causes the student to act in a manner that can be interpreted as an indication that he or she is confused, anxious, troubled, or upset?

9. Does the student perceive that he or she is and/or can be successful within the context of the program?

10. Does the student feel that (s)he has the necessary capabilities to carry out the learning tasks (s)he is being asked to do?

11. How does the student react to unpredictable situations that may arise in the classroom?

12. Does the student welcome and/or look forward with pleasure to the time when (s)he has the program?

13. Does the student act in a manner that can be interpreted as indicating that (s)he is comfortable in the program? How frequently does he or she smile? How frequently does (s)he excitedly share new discoveries and ideas with others?

C. Adequacy of Program Evaluation Evidence

1. To what extent does the program evaluation provide evidence regarding the considerations delineated in sections A and B of this table?

2. To what extent does the program evaluation provide evidence regarding considerations about the program's content (see questions in Table A-2), instructional strategies (Tables A-3 and A-4), provisions for the teacher (Table A-5), provisions for student assessment (Table A-6), and implementation (Table A-7)?

3. Does the program evaluation consider how well the assumptions of the program match the beliefs of various types of communities?

4. Does the program evaluation consider which of the program's goals, if any, are incongruent with the social, economic, or political views of significant groups of people?

5. How much and what kinds of evidence does the program evaluation provide about the achievement of each of the program's goals?

6. Is the evidence presented in the evaluation report based on a formative or a summative evaluation of the program?

7. Is the design of the evaluation study described completely?

8. What are the strengths and weaknesses of the sampling procedures?

9. How generalizable are the findings of the evaluation?

10. Were the statistical analysis procedures carefully and correctly carried out?

11. Are data reported as percentages or proportions to mask the fact that actual numerical sizes of samples were quite small?

12. Are elaborate graphs or extensive tables of data used to display trivial or not highly pertinent information?

13. If a revised version of the program exists, were the data presented in the evaluation report collected on a previous or the revised version of the program?

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Table A-9

Developers' Qualifications

A. Characteristics of the Major Developers

1. Is there evidence that the major developers have sufficient knowledge of the academic disciplines relevant to the program's content, instructional methodologies, and characteristics of the learner population to develop a program of quality?

2. Do the major developers have a broad range of knowledge and experience to bring to the development effort?

3. What are the previous experiences of the major developers that provide a basis for their success in an energy education program development effort?

4. Is there evidence that the major developers are highly regarded by their peers?

5. Are major developers committed to a certain philosophy of education? A certain psychological theory? If so, which one?

6. Is there evidence (e.g., previous writings in the field, educational background) that the major developers have had a long-term commitment to energy education?

B. Characteristics of the Development Team

1. Does the development team include persons with adequate knowledge of the content from all the relevant academic disciplines?

2. Does the development team include persons who are well acquainted with goal-setting strategies and values clarification techniques?

3. Does the development team include persons with expertise in instructional design?

4. Does the development team include persons with extensive experiences in the schools?

5. Does the development team include persons who are well acquainted with the complexities of implementing a new educational program?

6. Does the development team include persons with extensive experience in designing student assessment procedures?

7. Does the development team include persons with expertise in the design of instructional media and materials?

8. Does the development team include persons with knowledge of procedures in publishing?

9. Does the development team include persons with experience in the formative evaluation of a program under development?

10. Does the development team include persons who are knowledgeable about the techniques and procedures of program evaluation research?

C. Resources Available to the Developers

1. Is the development team associated with an established academic or research institution?

2. Is the development team associated with an organization having adequate prior experience in educational program development?

3. Are consultants representing a variety of academic and professional fields available to the developers?

4. Do the developers have easy access to children of the same age and learner characteristics as the program's target population?

5. Do the developers have easy access to schools representative of those for which the program is designed?

6. What library facilities are available to the developers?

7. What production facilities (art, photography, printing, woodworking) are available to the developers?

8. Are there sufficient financial resources available to the team to complete the development of the proposed program?

9. Will program development be a full-time activity for the developers?

10. Have the developers sufficient time to complete the program as it is specified?

APPENDIX B

Figures B-1 through B-5

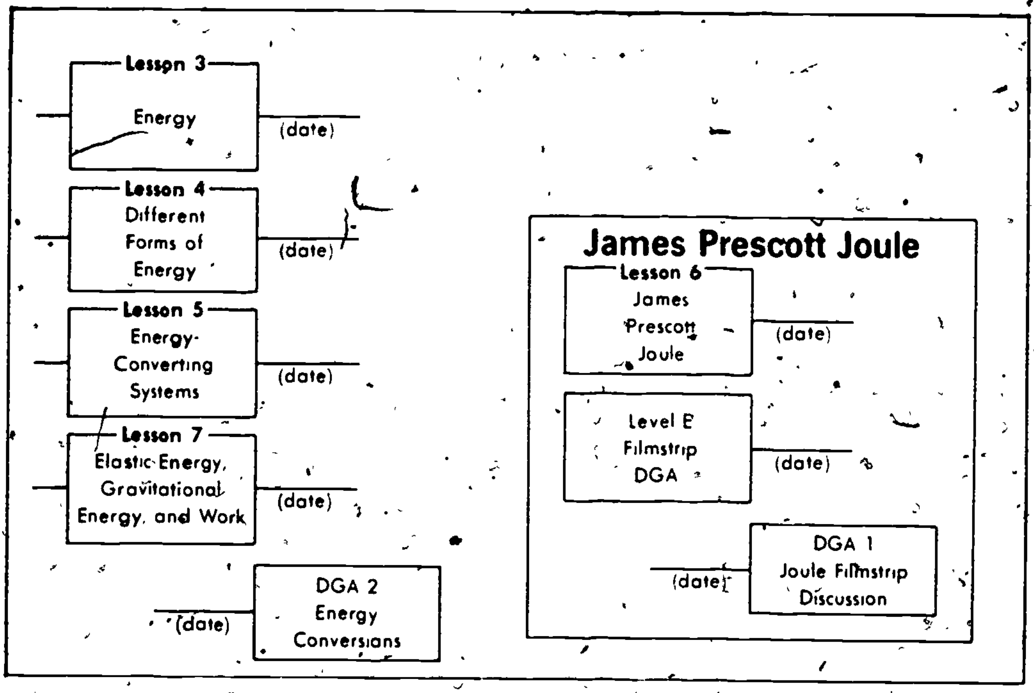


Figure B-1 Illustration of science content included in a science unit on energy. Joule Planning Booklet pp. 1-3 (from Champagne & Klopfer, 1974)

Work

Lesson 8
Doing Work
(date)

Fuel

Lesson 9
Fuel-Oxygen Systems and Energy
(date)

Heat Energy

Lesson 10
Measuring Heat Energy
(date)

(date)
DGA 3
Energy and Fuel

The Sun

Lesson 11
What If the Sun Went Out?
(date)

(date)
DGA 4
Fuels and the Sun

Figure B-1 (Continued)

Other activities about:	You can do these activities at any time.	Date:
Forms of Energy	☐ MinEx 1 Can Light Energy Change Things?	
	☐ MinEx 2 Is Sound a Kind of Kinetic Energy?	
	☐ MinEx 3 How Can You Make a System To Convert Heat Energy Into Kinetic Energy?	
	☐ MinEx 4 How Can You Make a System To Convert Stored Gravitational Energy to Kinetic Energy?	
	☐ MinEx 5 How Can You Make a System To Convert Electrical Energy to Magnetic Energy?	
	☐ MinEx 6 How Can You Make a System To Convert Stored Chemical Energy to Electrical Energy?	
	☐ SA 1 Batteries	
	☐ SA 2 Elastic Energy	
	☐ SA 3 Can You Show That Energy Has Mass or Occupies Space?	
	☐ SA 4 Community Electricity	
	☐ SA 8 Elastic Energy Machine	
	☐ SA 9 Energy Conversions	
	☐ SA 12 Observing Sound	
	☐ SA 13 Paper Cup Telephone	
	☐ SA 14 Radiometer	
	☐ RIS 1 A Chemical System	
	☐ RIS 2 Fireflies	
	☐ RIS 3 Gravity	
Work	☐ SA 6 Gravitational Energy	
Fuel	☐ SA 5 Fuels	
Heat Energy	☐ MinEx 7 How Can You Make a System To Convert Electrical Energy to Heat Energy?	
	☐ MinEx 8 How Can You Measure Heat Energy?	
	☐ SA 10 What Happens When You Add the Same Amount of Heat Energy to Equal Masses of Salt and Water?	
	☐ SA 11 How Is Heat Energy Measured?	
	☐ SA 15 Energy Game	
	☐ SA 16 Energy Solitaire	
	☐ RIS 6 Calories	
The Sun	☐ SA 7 Solar Energy	
	☐ RIS 4 Nuclear Energy	
	☐ RIS 5 How Does the Sun Get Its Energy?	
	☐ RIS 7 Conservation of Energy	
"How To . . ." Booklets	You can find out more about doing science activities by reading "How To . . ." booklets. Some of the booklets are: How To . . .	

- Do SA's
- Do RIS's
- Do MinEx's
- Do SIIA's
- Use an Alternative Pathway Unit
- Answer Questions and Check Your Answers
- Use Your Science Notebook
- Treat Burns
- Use Glass Safely
- Use Chemicals Safely

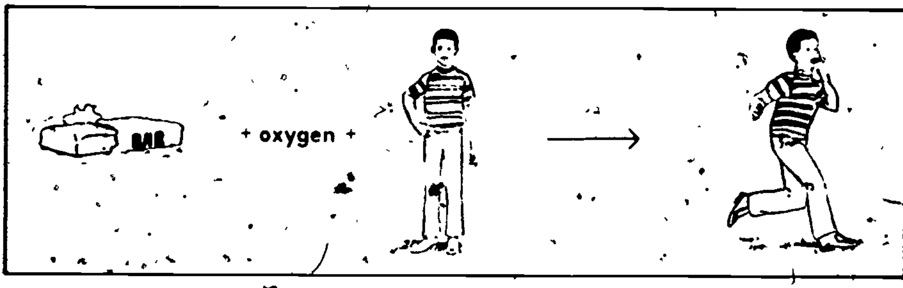
Figure B-1 (Continued)

Energy-Converting Systems

You will need a kit, an answer sheet, and a pencil. From Central Supply, you will also need two batteries, two rubberband battery holders, and four wires with alligator clips.

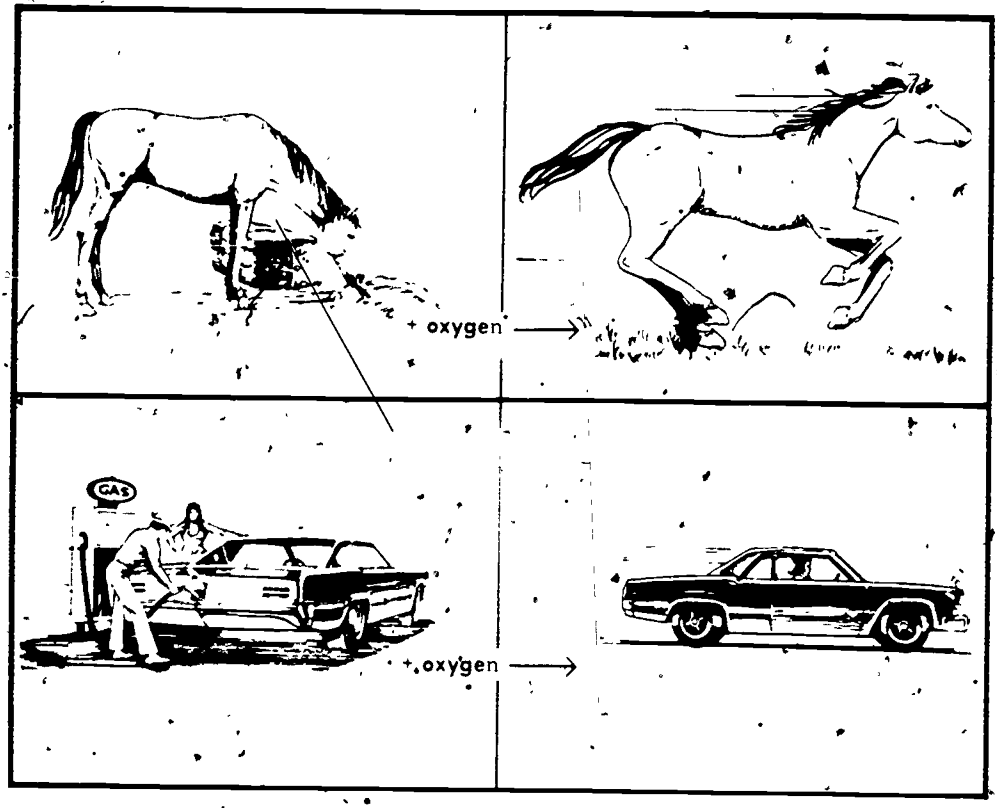
There are many different forms of energy. You have learned about heat energy, light energy, kinetic energy, sound energy, electrical energy, and chemical energy. Energy can be changed from one of these forms to another.

Chemical energy can be changed into other forms of energy. Chemical energy can be changed into kinetic energy, sound energy, light energy, heat energy, or electrical energy.



A boy is a system that changes or converts chemical energy from the food he eats and the oxygen he breathes into heat energy, sound energy, and kinetic energy.

Figure B-2 Illustration of a didactic instructional strategy "Joule Lesson 5, Energy Converting Systems." pp. 1-6 (from Champagne & Klopfer, 1974a).



A horse is a system that converts chemical energy from the hay it eats and the oxygen it breathes into heat, sound, and kinetic energy.

A car is a system that converts chemical energy from the gasoline and the oxygen it uses into heat, sound, and kinetic energy.

There are many different kinds of systems which convert one form of energy into another. Any form of energy can be changed into any other form of energy with the right energy-converting system.

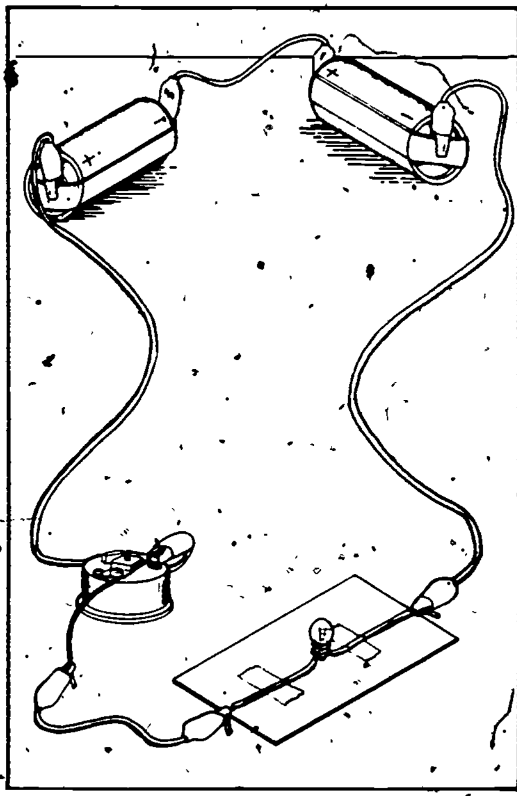
Figure B-2 (Continued)

Batteries, buzzers, and light bulbs are energy-converting systems.

Take the materials out of the kit.

Now look at the picture at the right.

Use the wires to connect the batteries to the light bulb and to the buzzer. When all of the connections are made correctly, the light bulb will go on and the buzzer will buzz.

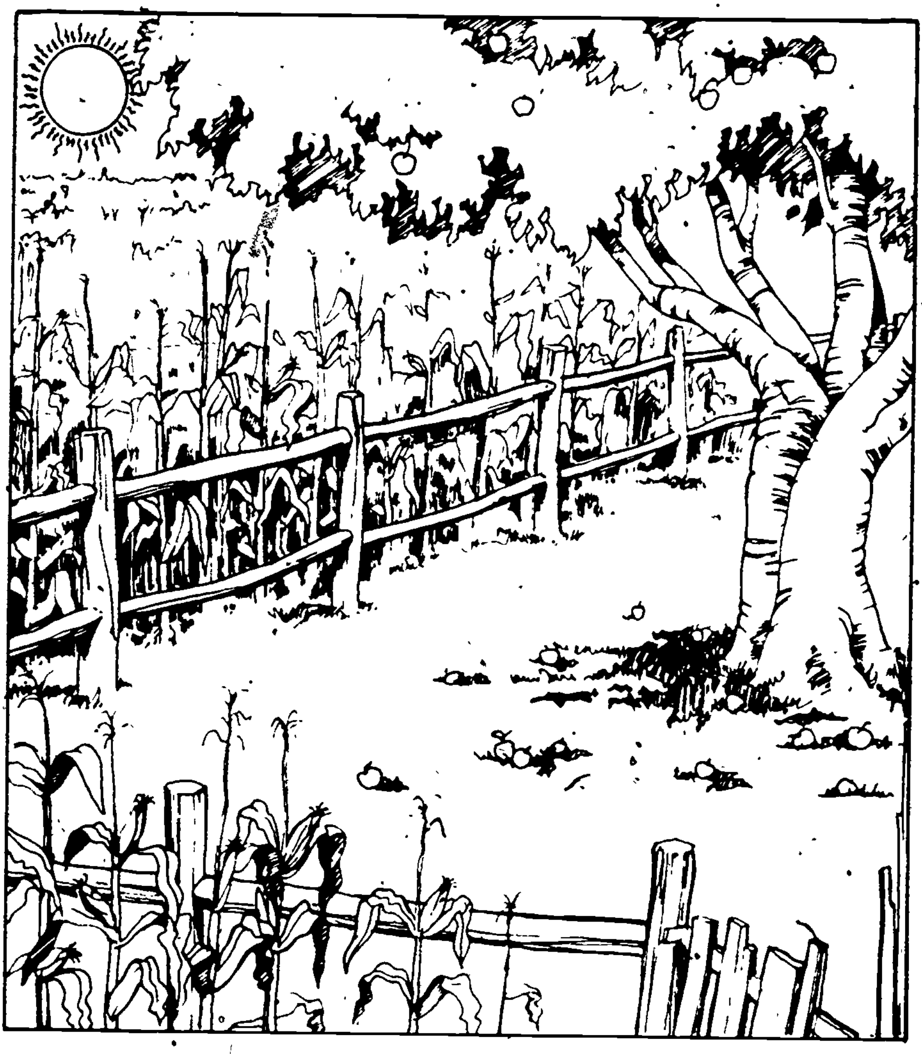


A battery is an energy-converting system that changes chemical energy into electrical energy.

A light bulb converts electrical energy into two other forms of energy. These forms of energy are light and heat energy.

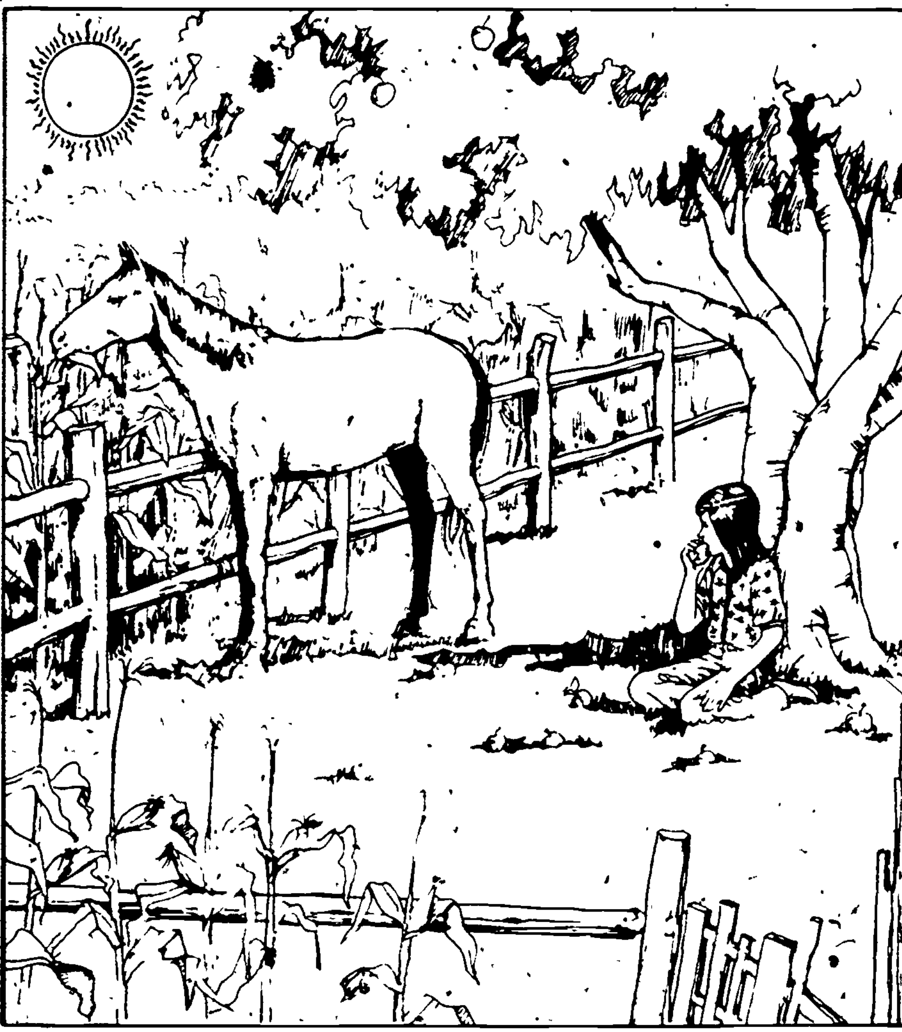
A buzzer converts electrical energy into sound energy and a little heat energy.

Figure B-2 (Continued)



Plants are important energy-converting systems. Plants use light energy from the sun to convert carbon dioxide from the air and water from the ground into oxygen and food (apples, corn, and grass, for example). The oxygen and food produced by plants are a system that has chemical energy stored in it.

Figure B-2 (Continued)



Animals are energy-converting systems too. Animals convert chemical energy from the food they eat and the oxygen they breathe into heat energy that keeps their bodies warm and into kinetic energy for moving about and doing things. They also convert chemical energy into sound energy when they make noises.

Figure B-2 (Continued)

1. When logs burn in a fireplace, what two chemical substances interact to release energy?

2. What form of energy is stored in a wood-oxygen system?

3. When the chemical substances in a wood-oxygen system interact, chemical energy is converted into other forms of energy. What are they?

Write your answers to all the numbered questions on your answer sheet.

Figure B-2 (Continued)

individualized SCIENCE

Imperial International Learning Corporation

Level E

Joule MinEx 3

How Can You Make a System To Convert Heat Energy into Kinetic Energy?

Things you will need for this MinEx:

kit	pencil
science notebook	

from Central Supply:

scissors	50 ml plastic beaker
small piepan	paper towel

from Teacher's Supply:

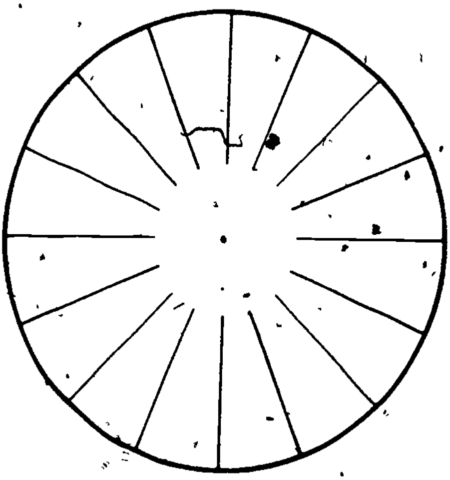
hotplate

> NOTE: If you have a different plan for answering the question, talk about your plan with your teacher.

Figure B-3 Illustration of a type of problem-solving strategy "Joule MinEx 3, How Can You Make a System to Convert Heat Energy into Kinetic Energy?", pp 1-4 (from Champagne & Klopfe 1974a).

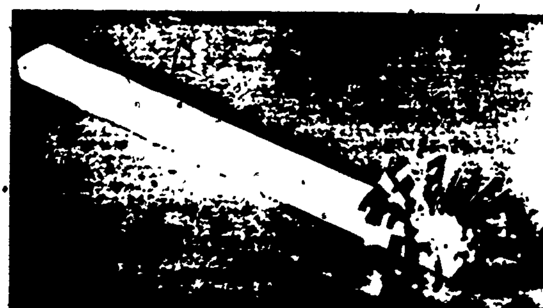
This is what Amy did.

First Amy got a small piepan. She cut around the bottom of the pan with a pair of scissors. In this way she cut out a circle of aluminum.



Amy made 16 equally spaced cuts in the aluminum circle. She was careful not to cut all the way to the middle.

Amy twisted each of the 16 blades a half turn in the same direction.



Then Amy pushed a map pin through the center of the aluminum wheel. She then pushed the pin into a long stick, so the blades of the wheel pointed out.

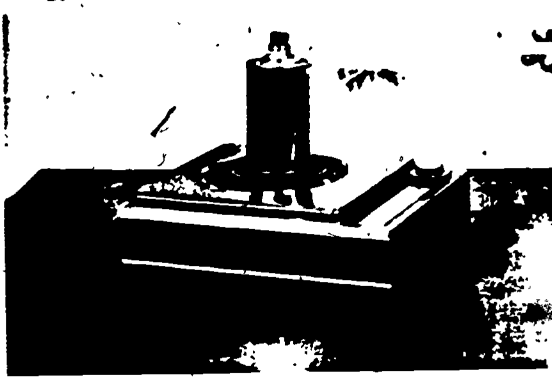
Then she set the stick and aluminum circle aside while she prepared the rest of her system

Figure B 3 (Continued)

Amy got a can with an opening in the top and a small hole in its side. She poured about 50 ml of water into the can.

Then she put a stopper in the top of the can to seal it.

Amy set the can on the hotplate and turned on the hotplate. She set the hotplate dial at 4. When she heard the bubbling of the water, Amy was very careful to keep her hands and body away from both holes in the can because she knew that steam is very, very hot. Amy picked up her stick. She held the stick so that the aluminum wheel was in front of the small hole in the can and a little above it. When she had done all this, she knew her system was converting heat energy into kinetic energy.



When she had finished, she turned o and unplugged the hotplate, and the asked her teacher to empty the can hot water.

Figure B.3 (Continued)

Can you think of another system to convert heat energy into kinetic energy?

If you try Amy's system, make sure that you are as careful as Amy was when working with steam. Remember to ask your teacher to empty the can of hot water when you are ready to clean up. You can keep your aluminum wheel.

What kind of energy conversion takes place in the can-and-wheel system?

Some Things To Write About

1. What form of energy does the aluminum wheel have when it is turning? How do you know?
2. What form of energy is added to the water in the can-and-wheel system? Where does this energy come from?
3. What kind of energy conversion takes place in the hotplate?

Some Things To Think About

1. Does the steam coming out of the hole in the can have energy? How do you know?
2. Why are there two holes in the can? Why do you put a stopper in the large hole?

Suggestions for Other Investigations

1. Set up your system again. Hold the aluminum wheel so that the steam hits the wheel in different ways. How should you hold the wheel so that it turns the fastest? When does it have the most kinetic energy?
2. Make wheels with blades that have different shapes and test them with your system. With what shape of blade does the wheel turn fastest?

Figure B-3 (Continued)

A Seminar on Energy

You will need your science notebook and a pencil.

What is a seminar? What happens at a seminar? This lesson will help you understand what a seminar is.

A seminar is a meeting of a group of people to report, to discuss, and to exchange ideas on a central topic. In a science seminar, scientists meet to talk about a scientific idea or question that interests all of them. Each scientist brings information to the seminar to share with the other scientists. Each scientist hopes to learn about some new ideas by taking part in the seminar. By sharing the information each scientist has found through his or her work, they hope to gain a better understanding of the question.

You could compare the way scientists work together in a seminar to a group of people planning a party. The party planners are interested in this question: What can we do so our friends will enjoy themselves at our party? The planners meet and combine their talents to work out an answer to the question. One person makes cupcakes and another makes punch. A third person decorates the party room and a fourth brings a record collection. By working as a group, the planners solve the problem of throwing a good party more easily than if one person planned the party alone.

Figure B-4 Illustration of a type of simulation instructional strategy "Joule Lesson 12, A Seminar on Energy," pp. 1, 6, 8, 9-11 (from Champagne & Klopfer, 1974a).

Introduction to the Seminar

The Level E seminar is a lot like an actual seminar scientists hold. Joule, Beaumont, and Voit are meeting to talk about this question: How is the food an animal eats related to the quantity of energy the animal uses?

Each man has done different work that is related to the seminar question. Joule studied energy. He found that energy is not lost or gained when it is converted from one form to another. Voit studied one particular energy-converting system, the human body. He tried to find a relationship between the chemical energy stored in the food an animal eats and in the oxygen it breathes and the amount of heat energy an animal's body releases. Beaumont looked inside a human being's stomach and observed the way food is digested.

While the three scientists in the Level E seminar share what they know about the seminar question, they gradually learn more about the relationship between the food an animal eats and the energy it uses. Joule's work concerning the conservation of energy is helpful to Voit. Since Joule showed that energy is neither lost nor gained as it is converted from one form to another, Voit can say that the amount of chemical energy stored in the food an animal eats and in the oxygen it breathes is the same as the amount of heat energy its body gives off. Some chemical energy is converted into kinetic energy in the animal's body. This kinetic energy is later converted to heat energy. Even though the chemical energy in the food and oxygen is converted in the animal's body into other forms of energy (heat and kinetic), the amount of energy remains the same.

Figure B-4 (Continued)

The Seminar

This seminar will be an informal gathering of three scientists meeting to discuss a specific topic. Since it is informal, there will be no discussion leader to direct the order of comments from the scientists.

Place: St. Louis, Missouri
Setting: Parlor in the home of the wealthy Doctor William Beaumont
Time: 1850

William Beaumont would have been a deaf old man of 65 years when James Joule was 32 years old and had published papers on the conservation of energy, and when Carl Voit was only 19 years old and had yet to do his studies of nutrition. But, let's imagine that all three scientists are of similar ages and have achieved success in their fields of study.

The seminar begins with the scientists sitting comfortably and talking earnestly.

Voit (V): The topic for our seminar today is the relationship between the food an animal eats and the animal's need for energy.

Joule (J): The work of many scientists has contributed to our understanding of how chemical energy stored in food and oxygen is converted by the body into heat energy and kinetic energy.

Figure B-4 (Continued)

Beaumont (B): But my work on digestion was most important. I showed how the body digests the food.

J: *(Joule says with respect.)* Yes, Dr. Beaumont, but surely you must agree that Dr. Voit's studies with the human calorimeter are important, too.

V: And your idea of energy conservation, Mr. Joule. Without that, the calorimeter studies are meaningless

B: Calorimeter? I am familiar with Lavoisier's studies using a calorimeter but I know nothing of yours.

V: May I describe a human calorimeter to you?

B: Yes, please do.

V: This calorimeter is much like Lavoisier's. But with it we are able to make much more exact measurements than Lavoisier.

J: Ah yes, accurate measurements. Accuracy, that's the secret.

V: Here, gentlemen, is a picture of a human calorimeter.

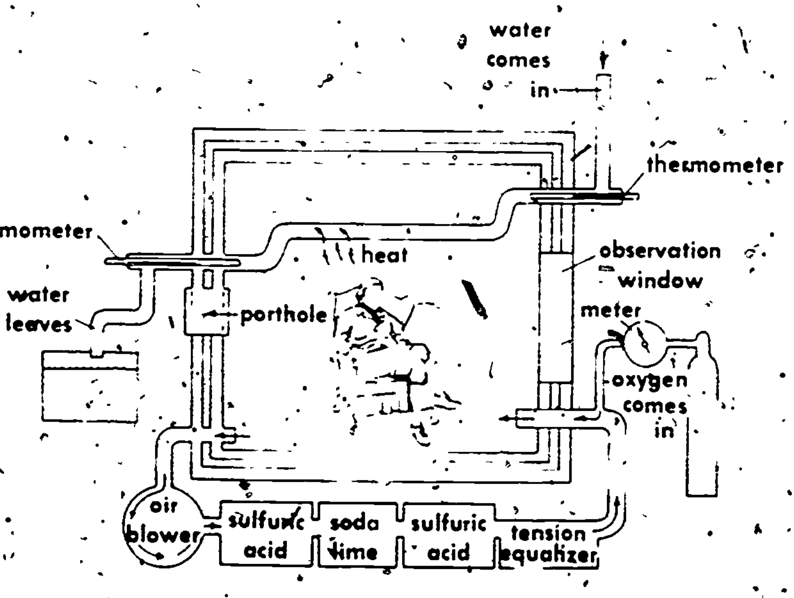


Figure B-4 (Continued)

As you can see, it is large enough for a person to sit in. *(Voit points to the person in the picture.)* The person gives off heat. *(He points to arrows and the word "heat.")*

There are two thermometers in the calorimeter. One is on the right *(he points)* and one is on the left *(he points).* The thermometer on the right measures the temperature of the water going into the calorimeter. The thermometer on the left measures the water's temperature as the water leaves.

B. And the temperature of the water that leaves is higher than the temperature of the water that enters? The heat from the person raises the temperature of water as it passes through the room?

V: Yes. The calorimeter is made so that none of the heat escapes through the walls. So, you see, my calorimeter is an energy-tight system.

B: What is so startling about all this? Everyone knows a person gives off heat.

V: With this calorimeter, Dr. Beaumont, we can measure how much heat energy is given off when the person eats different foods.

B: Now, that interests me. After all, I am the expert on how food is digested in the stomach. So you are saying that as food is digested, heat energy is made by the body.

J: I don't think Dr. Voit means that at all, Dr. Beaumont. Heat energy is not made by the body. The human body converts chemical energy stored in food and oxygen into heat energy. Energy is conserved; it can't be made or destroyed. Energy can only be converted from one form to another.

B: Please explain what you mean, Mr. Joule. I really don't see how all this talk about energy fits in with my brilliant studies of digestion.

J: You may think of the human body as an energy-converting system. The food we eat is changed by the body.

Figure B-4 (Continued)

B: That, Mr. Joule, I alone have observed with my own eyes.

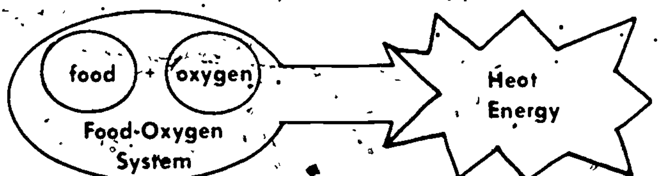
V: Yes, but as I have demonstrated, when the body changes the food we eat, energy is released.

J: You see, foods are made up of different kinds of chemical substances. Chemical systems have stored energy. This simply means that when chemical substances interact, the energy stored in them will be released.

B: What are these chemical interactions you speak of?

J: The chemical substances in foods interact with the oxygen a person breathes in. Oxygen is a chemical substance too, of course.

V: Here is a diagram to show what happens, Dr. Beaumont.



Imagine the person in the calorimeter has eaten some food. The chemical substances from this food *(Voit points to food)* interact with the oxygen *(Voit points to oxygen)*. This is the food-oxygen system *(he points to the large circle)*. In the body, the food-oxygen system releases its stored energy. Heat energy is given off *(he points to Heat Energy)*.

J: The main point is this, Dr. Beaumont. The amount of energy stored in the food-oxygen system is the same as the amount of heat energy released. The body cannot make energy. The body changes chemical energy into heat energy.

B: *(Beaumont says to Voit.)* Then the only energy that gets into the calorimeter is stored in the food-oxygen system. The only energy that comes out is heat energy. You measure the heat energy that comes out.

V: Yes. Mr. Joule has explained that the energy going into a system equals the energy coming out from the system.

Figure B-4 (Continued)

Joule Unit Science Content Overview

In seeking to describe the nature of the universe, scientists have found it useful to conceive of two basic components, matter and energy. That much is easy enough to say, but to fully and precisely define "matter" or "energy" turns out to be far from easy. Both of these concepts are subtle and elusive. In this discussion the focus is on the concept of energy, the subject matter of the Joule unit. As you will see near the end, however, a full discussion of energy cannot avoid the concept of matter, since there is an exact quantitative relationship between energy and mass, expressed in an equation that relates the two basic components of the universe.

Energy

In the Joule unit, your students are introduced to the concept of energy by noting the changes that occur in a system when energy is added to the system or when a system converts one form of energy to another form of energy.

Certain forms of energy can be observed in a system when the energy is transferred from one object to another. A rapidly moving hammer transfers its energy of motion, kinetic energy, to the nail it strikes. The hammer stops moving when it hits the nail, and the nail moves into the wood. Light energy striking a glass of iced lemonade is converted or changed to heat energy. The ice in the lemonade melts and, eventually, the temperature of the lemonade increases. Kinetic, sound, electrical, heat and light energy can all be observed to effect changes as they are transferred from one physical object to another.

Other physical systems have stored energy by virtue of their position, state of stress, or chemical composition. The fact that energy is stored in these systems becomes obvious when energy is converted to another form and is transferred to another physical object.

Gravitational energy is stored in an object when the object is lifted upward. To move the object, a force must be exerted through a distance. Work is done on the object to store gravitational energy in the object.

Elastic energy is stored in an object when that object is stretched or compressed. To stretch or compress the object a force must be exerted through a distance. Work is done on the object and elastic energy is stored in the object.

Chemical energy is the energy stored in two chemical substances. An example of two chemical substances with chemical energy is hydrogen and oxygen. When electrical energy is passed through liquid water, hydrogen gas and oxygen gas are formed. Energy is stored in these two gases as they are formed; later, they can interact. Hydrogen will burn as a fuel with oxygen, to release heat, light, and sound energy. A single substance does not contain chemical energy. Hydrogen by itself does not have chemical energy; it does not interact with itself to release energy. When two chemical substances interact, their stored chemical energy is rele[illegible]

Energy and Work

To store energy in any object or system, energy must be added to the system. To add energy to a system, work must be done on the system.

In the Joule unit, the concept of work is taught only in the context of gravitational energy and elastic energy. In this context, work is done when a force is exerted on an object, and the object moves in the direction of the force.

However, you should be aware that, whenever energy is added to a system, work is done on the system. For example, in the addition of electrical energy to water to form hydrogen gas and oxygen gas, work is done. Whenever energy is transferred from one object to another, work is done.

Figure B[illegible] An illustration of materials for the teacher: Excerpt from Joule Unit Science Content Overview (from Champagne & Klopfer, 19[illegible])

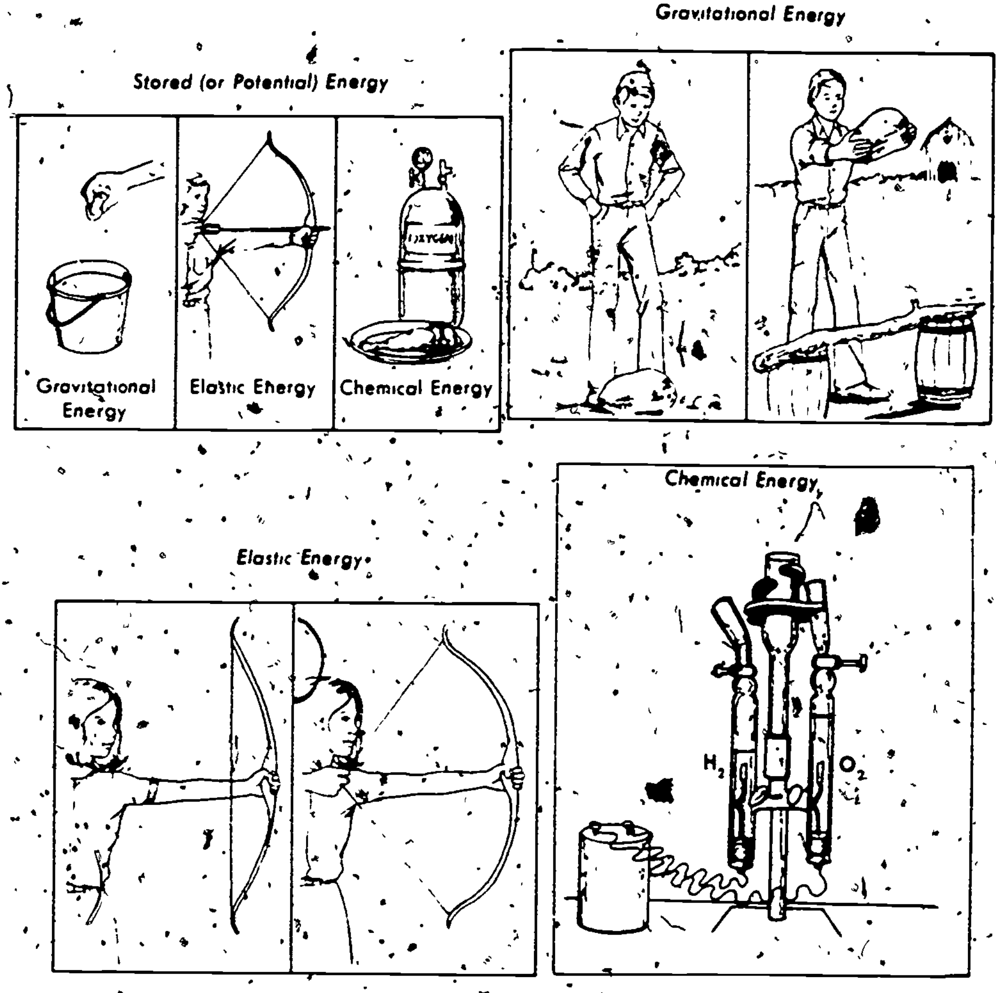


Figure B-5 (Continued)

Measurement of Energy

Different measuring units are used to express quantities of different forms of energy. In the Joule unit the student is introduced only to the measurement of heat energy in kilocalories. Equal masses of different substances do not change their temperature equally when the same quantity of heat energy is added to them. For example when equal quantities of heat are added to equal masses of water and alcohol, the temperature of the alcohol changes more than the temperature of the water. The kilocalorie, a measure of heat energy, is defined using water as a standard. To increase the temperature of 1 kilogram of water by 1 °C requires 1 kilocalorie of heat energy. To find the number of kilocalories (kcal) of heat added to any mass of water one must multiply the mass of the water in kilograms (kg) by the change in temperature in °C and by the specific heat of water (the heat necessary to increase the temperature of 1 kg of water by 1 °C, i.e., 1 kcal).

$$\text{heat energy} = \underset{\text{kg}}{\text{mass of water in}} \times \underset{\text{in °C}}{\text{change in temperature}} \times \text{specific heat of water}$$

$$\text{kcal} = \text{kg} \times \text{°C} \times \frac{1\ \text{kcal}}{1\ \text{kg °C}}$$

While heat energy is measured in kilocalories, other forms of energy are measured using different measuring units. The mathematical relationships between the various energy-measuring units are known, however, and there are calculations that equate different forms of energy that can be made. A measuring unit for kinetic energy is the joule, named to honor the scientist James Prescott Joule. One kilocalorie (heat energy) equals 4185 joules (kinetic energy). Using this relationship, a comparison can be made between the kinetic energy of a falling object and the chemical energy stored in sugar. Since 4185 joules = 1 kilocalorie, a 334,800-kilogram sphere falling with a velocity of 1 meter per second has the same energy as is stored in a tablespoon of sugar (40 kilocalories) and the oxygen needed to burn it.

$1\ \text{kcal} = 4185\ \text{joules}$

$1\ \text{joule} = 1\ \text{kgm}^2/\text{sec}^2$

$\text{kinetic energy} = 1/2\ (\text{mass})(\text{velocity})^2$

$\text{kinetic energy} = 1/2\ (334{,}800\ \text{kg})\ (1\ \text{m/sec})^2$

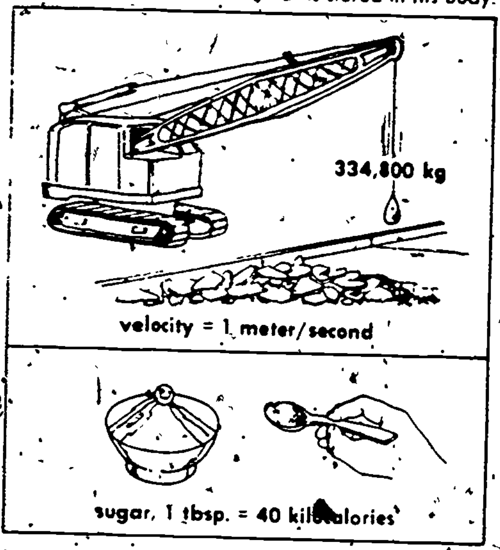
$\text{kinetic energy} = 167{,}400\ \text{kg} \times (1\ \text{m}^2/\text{sec}^2)$

$\text{kinetic energy} = 167{,}400\ \text{kgm}^2/\text{sec}^2$ or $167{,}400$ joules or 40 kilocalories

Measurements of energy as it is converted from one form to another have convinced scientists that energy is always conserved. These measurements never show exactly equal quantities of energy before and after the conversion, but the difference is so small that the conservation of energy is the best explanation scientists can give. So far as known, no energy is lost in a conversion, and no energy is gained. There are countless examples of the conser-

Figure B-5 (Continued)

vation of energy in science, many of which have practical implications in everyday life. One must spend the energy stored in the chemical system made up of food and oxygen to get energy for bodily warmth and activity. The amount of energy that one gets from chemical substances in food depends on the mass and the kind of food that is eaten. If a person eats more food than he needs to get the energy to keep his body warm and to move the parts of the body, his body will convert the extra chemical substances in food into fat that is stored in his body.



Sources of Energy

For human beings and other animals, food is the most important source of energy. For the earth, the sun is the most important energy source. Nuclear reactions on the sun release heat and light energy. This warmth and light gives our earth a constantly renewed supply of plant foods.

Coal and petroleum, two of our other sources of energy, were also produced by light energy from the sun. The formation of these substances required special conditions, though, there is little chance that they can be resupplied by the sun. As our supplies of coal and petroleum dwindle, scientists are exploring new energy sources, and we are constantly reminded not to waste the irreplaceable stores of these fuels that power our homes and industries.

Figure B-5 (Continued)